“LIGHT AND SOUND, NOT SONG AND DANCE”: CYBERNETIC SUBJECTIVITY IN THE ENVIRONMENTAL ART OF THE PULSA GROUP, 1966–1973

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Abstract

Throughout the 1960s and 1970s, the proliferation of computing technologies and their attendant futurisms prompted engineers and artists alike to reckon with a world humans would share with artificially intelligent machines. However, current scholarship around this period of techno-aesthetic experimentation lacks a full-scale exegesis of the work of Pulsa, an artist collective composed of seven Yale University graduates who lived communally and created programmed environments from 1967 to 1973. This thesis makes use of archival research and interviews to chart the arc of Pulsa's career, beginning with the light and sound environments they constructed in a New Haven loft and ending with their implementation of a feedback-enabled environment in which human movements elicited responses from a computational infrastructure. I characterize the group's iterative work process as moving toward *evolutionary environments* aimed at evolving the human perceptual panoply to better cope with a dawning cybernetic age. The audience's experience of a Pulsa environment bolstered this project in that the boundary between art and viewer or object and subject became blurry—the human and the machine were in fact interdependent. Eventually, Pulsa took their environments to the urban environment, where the dream of facilitating dialogue between computers and their users became an element of city planning. Finally, Pulsa's work evolved toward mutualistic feedback between participants and environment, where input from people in the space affected the system output. Rather than attempting to control participant behavior, I argue, Pulsa's interactive works created a networked environment in which action could occur and be fed back into the system. In the resultant social vision, control persists not in the overt control of behavior, but in the creation of seemingly endless opportunities for action within a system that learns from those choices.

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Thank you to Henry Lowood with Stanford Special Collections for securing the Pulsa archives for my and future scholars' research. Thank you also to David Rumsey, Michael Cain, and Patrick Clancy for sharing your experiences as original Pulsas. The late Gene Youngblood's immortal words serve as the epigraph to this thesis—I treasure the conversations we had, as they greatly expanded my understanding of what technology can be and do.

Last but not least, infinite thank yous to my family and friends for all their support.

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"The simulation of reality has delivered its
maximum performance; it no longer
benefits us as it has in the past."

— Gene Youngblood, *Expanded Cinema*, 108

Introduction

In 2019, Stanford University launched its Institute for Human-Centered Artificial Intelligence (HAI). This interdisciplinary center advances a research program at the forefront of emerging computational technologies, while ultimately striving to "bring a humanistic sensibility to the world in which we live."[1] This "world in which we live" implies one that we humans share with animals, plants, and machines, all of which are equipped with different and, in the latter case, "artificial" intelligences. The need to endow this pluralism of variegated modes of being with a "humanistic sensibility" betrays an anxiety, an ontological insecurity brought about by the prospect of machines that might someday outsmart their creators. What does it mean to be a human when machines start to think and behave like us? This concern is not a new one; always dovetailing with the proliferation of computing technologies since their inception during the Second World War, the question of what computers will *do to us* has loomed large in popular imagination.

Following these crises in humanism engendered by the rise of machines backward through time takes us to the 1960s and 70s, when the possibility of artificial intelligence took hold in scientific discourse and research. In response, artists took these tools and ideas as media through which they could express their own ideas for a future shared with machine intelligences. These comprehensive anticipatory design scientists, to borrow a baroque phrase from

Buckminster Fuller, endeavored to marshall the global village into the dawning Information Age by enacting a revolution of the senses.[2]

While the mission of Stanford's HAI Initiative certainly finds its ethical roots with these countercultural cosmonauts, the environmental artists of the 1960s and 70s operated under a thesis that breaks with HAI's "humanistic sensibility" in a key way. Rather than asserting a humanism that neatly separates artificial from "natural" intelligence, systems thinkers and design scientists imagined a mode of being expanded and distributed across many forms of embodiment and thought, both human and machine. These actors used the aesthetic, sensory experience as the site where participants might reorient their own subjectivity toward the kind of expanded mode of being proffered by the specter of ubiquitous computing technologies.

To navigate the explosion of subjectivity in cybernetic art practices, this thesis takes the work of Pulsa, an artist collective that experimented with programmed environments of light and sound from 1967 to 1973, as its compass. Made up of seven Yale University graduate students, this collective developed their own Hybrid Analog-Digital Synthesizer to automate sensory stimuli and approach two-way feedback between the human participant and the computational control system. Pulsa's work included public demonstrations, installations in the Museum of Modern Art, the Walker Art Center, and the Wadsworth Atheneum, and teaching positions at Yale and the brand-new California Institute of the Arts (CalArts). I have chosen Pulsa as a case study for two reasons: a) the group's work offers an especially fruitful site for understanding how the meeting of cybernetics and art in the 1960s and 70s enacted a novel understanding of how humans might subjectively understand themselves in a world shared with machines; and b) because current scholarship focused on the artistic responses to emerging computing

technologies lacks a comprehensive, large-scale study of Pulsa and their specific contributions to that milieu.

Literature Review

Of the most immediate concern in studying a group such as Pulsa is the creative use of technical media and the implications for art and art-making that arise therein. What did the emergence of computers mean for art, and what did art do for computers? Technical artefacts necessitate processes of production that in turn require management; when art enters that picture, it too becomes entrenched in the world of industry. In the context of post-World War II America, this picture is further complicated by its complicity in military research and development; the computation technologies and cybernetic theories that migrated into art-making were, after all, originally developed as war materiel.[3] These points of exchange between the military, industry, academia, and the arts also challenge our traditional notion of the artist-genius tinkering alone in his studio and creating art for art's sake, or even our idea of the high art world with its elitist galleries and auctions. For example, in *Making Art Work*, W. Patrick McCray shows how the Experiments in Art and Technology (E.A.T.) organization functioned like a consulting agency that matched engineers hoping to help artists implement the devices they designed into their creative practice.[4] McCray also tells the story of the Los Angeles County Museum of Art's short-lived Art and Technology program, which placed artists in residencies at technology companies. Fred Turner, too, has detailed the meeting points between the corporate world and the counterculture, wherein the business world gained some of the hippie fringe's cultural capital in exchange for institutional support of their artistic experiments.[5] The university acted as another site for facilitating collaboration between artists and industry; John Blakinger's work, for

instance, on Gyorgy Kepes and his founding of MIT's Center for Advanced Visual Studies (CAVS) exemplifies the role the academy played in art-technology experimentation of the 1960s and 70s.[6]

Where does Pulsa figure within this multinodal network of businesses, universities, militaries, artists, and hippies? The group adds an interesting wrinkle to our current understanding of art-industry-academy collaboration in that they had one foot in the free-wheeling world of communes and LSD, and one foot in Yale University's network of support and resources. Such connections between the counterculture and institutions were not uncommon, as Turner's study of Silicon Valley's hippie history has shown us.[7] This story of Pulsa, however, brings in the specific context of Yale's amenability toward aesthetic implementations of emerging technologies (building off Felicity D. Scott's scholarship on that university[8]), and also analyzes how Pulsa distinguished itself from the tie-dyed, hazy iconography of a group like USCO while not totally fitting in with the more high-art Minimalist crew of artists like Robert Smithson or Donald Judd.[9] Where scholars like John Beck and Ryan Bishop ground their critiques in this crossover between the research labs with military contracts and modern art,[10] my analysis of the Pulsa group focuses more on what the aestheticization of such technologies tells us about the speculative visions these artists held.

In his encyclopedic *Understanding Media*, Marshall McLuhan describes "abstract art" as "a central nervous system for a work of art, rather than the conventional husk of the old pictorial image."[11] In attempting to describe the aesthetic character of Pulsa's work, this element of nervousness, of sensitivity to the dynamics of the environment is absolutely central. The arc of the group's career begins with programmed displays of strobe lights and electronically-produced sounds, continues with the integration of their home-built analog-digital synthesizer, and ends

with an attempt at actualizing artificial intelligence.[12] Rather than churning out discrete objects, Pulsa instead pursued an iterative process of fine-tuning their version of the light-and-sound environment, inching ever closer toward true, mutual feedback between the technical apparatus and the participants in the space—toward creating a central nervous system capable of responding to the stimuli provided.

Though McLuhan uses the generic "abstract," the concerns and activities of Pulsa can be more specifically related to the post-World War II concern with humanity and its perceptual relationship to that which exists outside (though the boundary may not be so neat) its bodily confines—the *environment*. Art historian Larry D. Busbea offers the term "responsive environments" to characterize the activities of artists and art collectives like Pulsa.[13] Emerging insights from perceptual psychology, Busbea finds, greatly informed this area of aesthetic inquiry, which honed in on the question, prompted by the proliferation of increasingly "intelligent" machines, of how to mediate the inner experience of the individual and their outer world. Similarly, Molly Wright Steenson's characterization of the architectural appropriations of artificial intelligence highlights the attention designers like Nicholas Negroponte and Cedric Price paid to endowing a physical space with the ability, aided by computers, to communicate with its inhabitants.[14] Daniel Belgrad's survey of the resonances of cybernetic thinking within creative experimentation of the 1970s further elaborates the notion of the artistic environment as an interaction between individual people (or "users") and increasingly computational systems of organization.[15] Charissa Terranova's account of the interface between systems biology and art, James Nisbet's study of land art, Pamela Lee's treatment of the role time played in arts of the environment, and Michel Oren's investigations into collective art-making similarly sketch the

encounter between post-World War II scientific and technical innovations and experimental art practices.[16]

While the work of these scholars in defining the environmental aesthetics of 1960s-70s non-object artistic output provides the foundation of this thesis, my study of Pulsa fills in some details of the current picture of this art historical period. Pulsa's aim to create opportunities for mutualistic dialogue between man and machine through light-and-sound environments allows me to explore the subjective experience of the audience, how it differs from traditional aesthetic experiences, and where the artist and the question of control fit into this picture. I characterize Pulsa's work as *evolutionary environments* that simultaneously promote the evolution of the participants' consciousnesses through perceptual activation while the environment itself is endowed with the capacity to change in response to human behavior. The evolutionary environments of the Pulsa group shift the traditional notions of aesthetic subjectivity toward a systems view in which the mutualistic relationship between participant, environment, and control mechanism dissolves the boundaries between each entity. If Pulsa's evolutionary environments promised to liberate the human sensorium from culturally-ingrained but now outmoded cognitive processes, how did the group position themselves as designers and operators of the technical systems that facilitated this ritual of consciousness expansion? To answer this question, I turn to insights from second order cybernetics, which offered Pulsa a formula for abstracting the threat of their own control over participants.[17]

If cybernetics, the theory of communication and control proffered by Norbert Wiener in the 1940s, promulgated an understanding of how systems function and evolve, second-order cybernetics sought to include the observer itself into that view.[18] Literary scholar N. Katherine Hayles examines the ramifications of such developments in cybernetic thinking for literature,

illustrating how scientists and writers alike wrestled with the boundary between the "outside" and "inside" of systems.[19] Mark Hansen breaks with Hayles in the implications of second-order systems theory on this point of the boundary; where Hayles sees a constant power struggle between the inside and outside positions, Hansen adopts a "system-environment hybrid" model wherein the system retains operational closure while still incorporating the larger context of an incomprehensibly complex total environment.[20] Sociologist of science Andrew Pickering takes the centrality of this unknowability to neo-cybernetic theories and explores its ramifications in the cultural output of the mid-twentieth century.[21] Such discussions of inside and outside, of system and environment are key to understanding how Pulsa understood their own relation to the control systems they developed. By drawing out this connection between the artistic experimentation with the computational tools developed after World War II and contemporary studies in second order cybernetics, this thesis offers a novel perspective on a question largely missing from discussions of artists and art collectives like Pulsa. That question asks how the spatialization of computing technologies, the turning of every surface into a panoptic system, tends to look a lot like behavioral monitoring, and how these artists, who hoped to liberate the individual, strove to mitigate control. Where some scholars, like Pickering, exalt second order cybernetic thinkers for their refusal of top-down planning, I argue that while such thinking might enable perceptual liberation for the individual, its manifestation in Pulsa's artistic output illustrates the avenues by which power mutates and re-emerges when neo-cybernetics is scaled up to the level of population.

In studying the output of a group like Pulsa, there emerges a chasm between the environments they actually created and the utopian aspirations underlying them. While the physical works were limited by technical constraints, the group's documentation, writings, and

media coverage gesture toward the possibilities for artificially intelligent environments and human-computer interaction. In other words, Pulsa's work functioned much like a proof-of-concept for a vision of a cybernetic world. In this divide between the aspirational and the real emerges another quandary; though Pulsa's evolutionary environments focused on the individual sensorium, they also envisioned such principles of mutualistic dialogue administering the whole of society. Architectural historian Felicity D. Scott has illustrated how systems-oriented artists like Pulsa prototyped a kind of politics without politics, or a government that replaces contestatory political action with automated technical systems that view the health of the polis in terms of growth, decay, and feedback.[22] My account of Pulsa's utopian speculation tracks Scott's work while connecting these dreams back to the question of the state of the human. If, in a Pulsa environment, a participant's behavior becomes quantified by a central control apparatus, does the human become a mere number, a simple one or zero that triggers an algorithmic sequence of events? At the individual level, these evolutionary environments aim to aid the perceptual evolution of a human being on the cusp of a digital world; taken from the perspective of the control system driving that experience, however, the participants become little more than data.

Ultimately, this thesis tells the story of Pulsa's participation in an artistic and cultural movement that used emerging technologies to involve humanity in an evolution of perception. More generally, looking toward this history of artistic implementations of emerging technologies invites us to reflect on our present. If works like those devised by Pulsa aimed to integrate computational technologies into society in such a way as to promote the evolution of humanity, how does that history live on in our current conception of human-computer interaction? How did the systems-oriented subjectivity with which Pulsa imbued their environments inform the emergence of a social reality in which humans live all watched over by machines of loving

grace?[23] The ideas espoused in the Pulsa archive offer a genealogy of what it means to be a human in an age of responsive architectures, information overload, and computers that constantly monitor our behavior.

Roadmap

This thesis unfolds in three parts and follows a loose chronological line through Pulsa's lifespan. In Chapter 1, I focus on Pulsa's early experiments with light, sound, and space to illuminate the historical and conceptual underpinnings of the environmental arts movement; what inspired the move from canvas to existing space, from paint to "experience"? Chapter 2 looks at the myriad connections between environmental art and urban planning, and the sociotechnical vision that intersection espoused. As Pulsa took their work out of the academic playground in which the group was born and into the public realm, what were the implications of their instrumental social purpose of evolving perception for the urban environment? Finally, in Chapter 3, I take up the later portion of Pulsa's oeuvre, which approaches space endowed with artificial intelligence. Here, Pulsa's work evolved toward mutual feedback between participants and the environment, where input from people in the space affected the system output. In conjunction with this progression toward two-way interaction, Pulsa addressed the implications of behavioral manipulation by introducing digital logic, answering the problem of control with complexity. This turn shares conceptual attributes with insights from second order cybernetics, which attempts to explain how new phenomena "emerge" under system constraints.

How did the evolutionary environments of Pulsa contribute to a reimagining of the relationship between humans and emerging computational technologies? In attempting to mitigate control and enact an expansion of human consciousness, where do power and control

mutate and reemerge in these environments? Scholars like Busbea, Belgrad, Scott, and Terranova have focused on the connection between scientific discourse and the artistic output of 1960s-70s environmental artists. Still others, including Beck, Bishop, and McCray, focus on the exchanges between industry and the avant-garde, and the shifting notions of the artist's social function that arise therein. This thesis picks up both of these threads of inquiry while remaining firmly rooted in the specific example provided by Pulsa and the question of how such creative experimentation radically reconfigured the aesthetic experience in order to elicit the perceptual evolution demanded by an age of information. The evolutionary environments of the Pulsa group prototyped spaces in which humans might engage in harmonious dialogue with computers. However, when utopian dreamers like Pulsa scaled up this vision to administer the entire urban experience, issues of behavioral control emerged; in response, I argue, Pulsa adopted language that resonates with contemporary discourse around second order cybernetics in order to abstract the imposition of their own role as system designers.

Chapter 1: Evolving Perception through Environments

In the winter of 1967, David Rumsey invited Michael Cain and Patrick Clancy to help him transform his Orange Street loft into a space where pulsating patterns of light and sound would submerge visitors in a bath of perceptual phenomena. To do so, the group salvaged fluorescent tubes, sound-on-sound recorders, tape decks, and tube amplifiers from a nearby military surplus yard. They constructed banks of lights and rigged the frequencies of the electronic soundscape to trigger the intensification of brightness. When the guests arrived, the overhead lights would turn off, washing the room in total darkness before flashes of lights and clicks of sound electrified the space.[1] Viewers described the experience, which Pulsa called *Program 3*, as a sequence of phases—the initial flurry of stimuli was exhilarating, the next ten minutes were monotonous, but then a trance-like state overtook one's mind, integrating the guest's consciousness into the attack and decay of the lights, the cyclical panning of sound.

What compelled this trio of MFA students with educational backgrounds in filmmaking, painting, poetry, and art history to take their aesthetic ideals out of the canvas and off the page and apply them to the amorphous, multi-dimensional realm of the environment? What do we even mean by *environment*? In this chapter, I dissect the constellation of ideas and movements with which Pulsa engaged and how they worked in concert to form the group's experiments with sense and experience. Looking closely at two of Pulsa's early installations, I consider how light and sound were organized to affect participants' perceptual relationship with the world around them. I characterize these endeavors as *evolutionary environments* aimed at retraining the human sensorium to acquaint citizens of the burgeoning information age to their increasingly electronically enhanced ecosystem. To begin, however, it is necessary to excavate the precise

role of an "environmental artist" as a departure from the traditional function of the artist, as well as the shifting teleologies of art itself.

Figure 1. Still from *Program 3*.

Pulsa Group, "Image - Pulsa Loft New Haven, CT Fluorescent Patterns 1967." *Internet Archive*.

Art as Research, Artist as Scientist

The core membership of Pulsa consisted of seven men: David Rumsey, Michael Cain, Patrick Clancy, Peter Kindlmann, Bill Crosby, Paul Fuge and Bill Duesing. However, they considered the individual formally subordinate to the whole; for example, when speaking to the press, they issued statements as a unified Pulsa rather than from unique representatives.[2] Each member brought a different set of skills and experiences to the group, but the technical and artistic specialists were to be considered equals. Each member had an intimate familiarity with all aspects of a given project regardless of his educational training so that specialization, in theory, would become irrelevant. Intelligence, in other words, was horizontally distributed

among the group such that variegated inputs and ideas could be considered synergistically without the controlling imposition of a predetermined program. Jack Burnham, art critic and bellwether of the rising artistic implementations of information technology, praised Pulsa's collective model, identifying the group as a representative of "a new breed of artists" for whom "all esthetic and technical decisions are shared equally."[3] This model of collaborative creation counters that of the Experiments in Art and Technology group (E.A.T.), a contemporary and interlocutor of Pulsa led by artist Robert Rauschenberg and former Bell Laboratories engineer Billy Klüver. The E.A.T. system functioned much like a consulting agency in which artists interested in experimenting with emerging technologies would be connected to a technical expert to help them execute their visions.[4]

Within this distributed collectivity that figured each group member as a node contained in a networked grid of intelligence, Pulsa viewed art-making not as a romantic distillation of artistic genius or individual aesthetic inclination but as systematic experimentation informed by feedback with the environment and given media. In the course of experimentation in the New Haven loft, which resulted in the *Program 3* performance described above, the group discovered that when they wrapped wires around the outside of a fluorescent tube, the frequency signal of the sounds travelling along the wires would ionize the gas inside the tubes. This process altered the brightness of the light in accordance with the intensity of the audio element. Further, the ionization of the gasses inside the fluorescent bulbs made a slight pinging sound when fired.[5] Pulsa utilized this chance occurrence by recording the audible reaction using sound-on-sound recorders, adding a delay, and then amplifying it back into space. This process of experimentation and the unanticipated findings that occurred therein relied on an open dialogue between the members of Pulsa and the materials with which they worked. The group did not

position themselves as masters exerting their creative will over the media of light and sound, but rather acted like scientists responding to the results of a test and incorporating new findings into their paradigm.[6] Rejecting the imposition of complete artistic control over their media, Pulsa instead enacted a cybernetic model of artistic production in which "artist" and "material" were situated on a horizontal plane with feedback determining the outcome of the performance. As a departure from the traditional portrait of the artist, Pulsa's collective, experimental artistic process integrated the artists, alongside their tools and the audience that would later view the work, into a larger system of production, a cycle of inputs and outputs.

With the conception of creative practice as applied research, the production of complete objects would be antithetical to the group's understanding of art-making continually informed by a feedback loop connecting themselves, the media with which they worked, and the environments in which they experimented. Given this, Pulsa's entire oeuvre can be considered a progressive arc with each installation elaborating upon the last. The group wrote about their orientation toward iteration over final products as "a long term evolutionary process the result of which would not be environments or phenomena, but an increasing generalized knowledge of and associated instrumentation for generating and controlling phenomena."[7] The environments Pulsa created, then, were not the ultimate goal or end result of their artistic experimentation; rather, these works were elements in a research process aimed at investigating and expanding human consciousness through the materials of perception.[8] As Pulsa progressed through the seven-year span of their career, their installations evolved to incorporate more channels through which participants' behavior could affect the output of the environment's control system and in turn be perceptually transformed by their experience.

Yale A+A: Training "Architects of the Electric Present"

Pulsa's early experimentation in the configuration of light and sound in space drew in faculty from the Yale School of Art and Architecture. This attention should be read within the morphing pedagogical context of Yale A+A in the 1960s, a period in which new faculty encouraged collaboration across disciplinary lines and embraced the kind of multimedia experimentation seen in the Happenings of New York City and the psychedelic rock shows of San Francisco. Prior to the appointment of Charles W. Moore to the chairmanship of the Architecture department in 1969, the aesthetic program of the school was informed by a Modernist yearning for a material instantiation of liberal politics.[9] Even the very building that housed the School of Art and Architecture, designed by former dean Paul Rudolph, epitomized Modernism's translation of social order into physical structures. As students' political consciousness became shaped by the atrocities of the Vietnam War, the subsequent student protests, and the Black Power Movement, Brutalist structures like the Paul Rudolph building came to represent the physical instantiation of authoritarian control. Yale heard the demands of its students and responded by turning away from Modernism's insistence on social and spatial control through the built environment and toward an embrace of the kinds of immaterial, electrified, mixed-media experiments happening in neo-avant-garde circles.

Arriving on a California breeze, Charles Moore radically departed from the Modernism of his predecessor. In a 1967 article for architecture journal *Perspecta* titled "Plug It in, Ramses, and See if It Lights up. Because We Aren't Going to Keep It Unless It Works," Moore employed his characteristically irreverent tone to call for "an architecture of the electric present."[10] Rather than creating place through physical form like the old Modernist guard, Moore encouraged his students to become "architects of inclusion" who would organize space using "electronic, not

visual, glue." This dictum takes a distinctly anarchic tone when the new dean describes how pyramidal chains of authority, architecturally reflected in the "hierarchic visual order" of Modernism, had become largely irrelevant except in oppressive institutions like the military and the government, echoing the rallying cries of students protesting on the streets. As such, Yale Art and Architecture affirmed, or at least played along with, its students' antipathy toward top-down control and reflected a growing faith in electricity and information as the path toward individual freedom. A similar pedagogical realignment occurred under Howard Weaver, dean of the School of Art, who believed that "the impact of science and technology affects every aspect of the concerns and explorations of those who would aspire to assume responsibility for art and design—for pondering man's seeing and feeling and moving about, his relationship to his environment, and his conscious ordering of his physical circumstances."[11] Here, Weaver connects the proliferation of technological advancements to a need to attend to the perceptual relationship between humans and their surroundings. This formulation gets at a key concern of artists like Pulsa: that the world had become suddenly alien to those who inhabited it. The responsibility for filling the existential and psychic void between technology and the human fell upon artists, whom people like Weaver and Moore believed could imbue the dark, satanic mills of industry (which had actually morphed into the immaterial bits and bytes of computers) with aesthetic potency such that people might become better equipped to understand the world around them and cope in a cybernetic age.[12] The Yale School of Art and Architecture of the late 1960s thus became a hotbed of cross-disciplinary collaboration that positioned itself at the crest of new media development, generating the institutional support Pulsa required to mount their own experiments.

In addition to the broader climate at Yale A+A, Pulsa garnered the direct attention of certain faculty who were sympathetic to new media experimentation. In *Eye*, the magazine of the Yale Arts Association, School of Art dean and Abstract Expressionist painter Jack Tworkov identified Pulsa's loft experiments as a significant breakthrough in the proliferating light-and-sound environment movement.[13] Praising the "merciful absence of any effort either to entertain or lobotomize the witness," Tworkov heralds a minimalist focus on the careful arrangement of perceptual phenomena so as to elicit an evolution of the viewers' sensorium. Pulsa's evolving work process would continue this turn away from imagery and toward non-representational patternings of the basic units of human perceptual faculties. Concluding his *Eye* piece on Pulsa, Tworkov suggests that in addition to light and sound, this new "medium" should expand to more carefully consider the "space in which it all happens." It is within this institutional shift that Pulsa dialed their attention into that space between the viewer and the artwork; or, more accurately, the group focused on dissolving that chasm between art and audience.

What is Environment?

In a sort of manifesto that traces the contours of the burgeoning environmental art movement in 1968, Pulsa ambitiously pronounces that the central concern of these artists is (or should be) "the exploration of the ultimate relationship of human perception to all possible environments through an abstract plastic experience not necessarily involving direct cognition of any aspect of environment, but enriching and integrating all aspects."[14] The assumptions underlying this statement are many; first, Pulsa insists on there being such an "ultimate" or universal connection between humans and "all possible environments," and that the realization of that connection lies in perception. Further, the relationship between the human and that which

exists outside its fleshy boundaries can be explored through an "abstract plastic experience" that appeals not to the faculties of reason and rationalization, but to our senses. This direct perceptual engagement weaves together seemingly disparate qualities of the environment into a totalizing whole so that even the line that demarcates where the human ends and environment begins dissolves into an integrated oneness. It was only through immediate activation of the senses, Pulsa believed, that humankind could meet the existential challenges that awaited them. Before delving deeply into these definitions of environment and the vision of the world they promoted, I will turn to Pulsa's contribution to *Project Argus* as a site for exploring the media and methods employed to construct those sensory spaces.

As a manifestation of their embrace of new artistic practices, the School of A+A organized a two-part event in April of 1968: a conference on computerization in architecture and a complementary multimedia installation titled *Project Argus: An Experiment in Light and Sound Environment*.[15] Dean Moore and faculty member Felix Drury joined in the students' rejection of their Modernist predecessors and worked with them to transform the Rudolph building into a dynamic testing ground for the school's initiatives in the study of programmed environments. This team erected temporary structures within the Rudolph atrium, and Jack Tworkov invited Pulsa to mount their strobe and sound installation in the temporarily transformed building. By this time, Pulsa's membership had expanded to include former architecture student Bill Duesing, light and sound artist Bill Crosby, psychology undergraduate and electronics hobbyist Paul Fuge, and Yale Electrical Engineering lecturer Paul Kindlmann. With the full roster established, the group set out to expand the technical capabilities of their light-and-sound installations. Kindlmann and Fuge led the project of creating an original design for a modular synthesizer that would allow the group to automate the production of light and sound while remaining accessible

to non-technical members of the group (recall the horizontal distribution of intelligence the group advocated). The resulting device, known simply as the Hybrid Analog Digital Synthesizer, represented a significant advancement over the dominant (but still quite young) Moog and Buchla systems in that no distinction was made between signal and control frequencies. I will return to the specific technical affordances of the Pulsa synthesizer and the ideas they reflect when I discuss sound at a later point in this chapter; I mention it here because *Project Argus* saw the first use of the Hybrid Analog Digital Synthesizer in a public Pulsa exhibition.

While some members of the New Haven community attended this public exhibit, *Project Argus* mostly catered to academic and high art crowds. An article from the *New Haven Journal-Courier* recounts that "even senior Yale professors were standing absent from the crowd, playing their hands and fingers in arcs through the air, chuckling at the staccato images—all they could see."[16] Others felt their senses were bombarded and assaulted, with one attendee remarking that "in the hands of some very unhip people … it could do some dangerous things."[17] This apprehension around the intentions of those directing the system signals a wider concern with the implications of behavioral control in responsive environments. Though Pulsa opposed "the mechanistic, Pavlovian stimulus-response training situation [that] brings out base responses from the audience and centers around ideas of environmental control," the group exercised a heavy hand over the sonic and luminary outputs and their subsequent effects on viewers.[18] *Yale Daily News* writers documented Pulsa members adjusting the frequency and amplitude controls on their synthesizer, noting how "the pulsa bent over his control panel, [and remarked,] 'Watch what they do now …'"[19] To what end, then, did Pulsa manipulate the sensory stimuli that populated their work? What effect were they hoping to elicit from their audiences when they exercised control over their senses? Chapter 3 will expand the charge of maleficent control and

Pulsa's strategies for mitigating it; to foreground that discussion, I will now probe the alternative readings of traditional conceptions of the "environment" that arose from the cybernetic intellectual milieu and how that discourse provided Pulsa a theoretical foundation upon which to construct their own take on controlled environments. I will analyze these new ontologies of space through the variegated modes of Pulsa's artistic process before turning to broader considerations of the preconceptions of the human-environment dynamic.

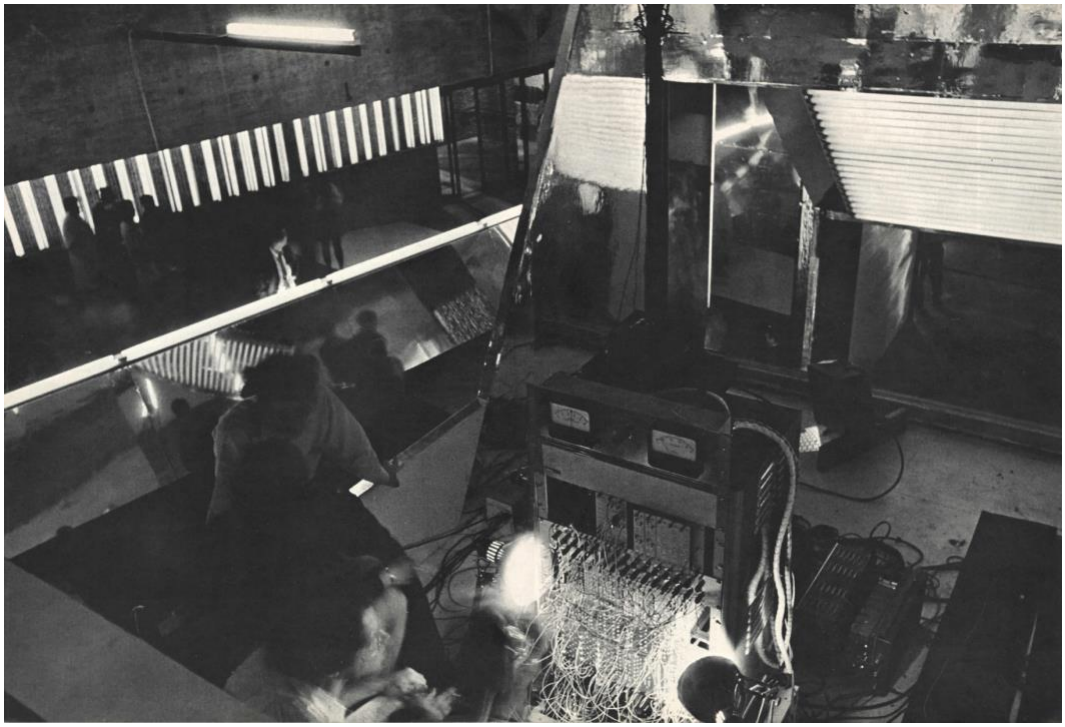


Figure 2. View of the Hybrid Analog-Digital Synthesizer in *Project Argus*.

Pulsa Group, "Image - Pulsa synthesizer and programmers In Pulsa Light/Sound Installation, Project Argus, Yale School of Art and Architecture, April 1968." *Internet Archive*.

Direct Sensory Engagement

Reviewing Pulsa's early light-and-sound work for a December 1968 feature in *Arts Canada*, critic Lucy Lippard notes that "the high speed at which the light and sounds were

relayed into and out of one's vision, hearing, and mental focus seem to bypass the associative channels of the brain."[20] The attack and decay of the strobe lights and the blips and bloops of the electronic sounds were not intended to task participants with the mental gymnastics of connecting their experience of an installation with some abstracted higher meaning. Rather, Pulsa environments existed as "a factual, physiological experience … the rate and scale of which resemble the neuro-electrical basis of human consciousness."[21] The sensory stimulants that suffused participants' consciousnesses were informative of nothing but themselves, of the process by which information cycles between the environment and the "psychophysiological" processing of humans. In working with the raw materials of perception, then, Pulsa decentered reason as the means by which humans come to know the environment around them; rather, Pulsa asserted that through direct sensory engagement, people can better understand and interact with their unstable surroundings.

In this turn away from abstract reasoning and toward perceptual engagement, Pulsa strove to do away with representation and imagery. Of immediate concern to group members were the ways in which "continuous light, melodic music, and referential art … combine in insidious ways to create a rigid perceptual attitude which shapes our raw perceptions into a world we have been made to see."[22] Though members of Pulsa were certainly "made to see" the world partly through experimenting with psychedelic drugs and listening to rock n' roll groups, the symbologies of these cultural affinities did not make their way into Pulsa's aesthetic program. Pulsa specifically distinguished their work from these extracurricular activities, describing *Program 3* as "unlike 'psychedelia' in that it is neither imitative of experience nor phantasmagoric."[23] As Lippard remarks, the patterning of light and sound was "so powerful a phenomenon in itself, [that] these experiences have seemed sufficiently informative about

themselves and their surroundings to block anecdotal and Rorschach responses."[24] These kinds of associative responses, in Pulsa's view, conditioned humans into reducing their experience of reality into metonymic proxies that took away from the raw truth of its totality. As such, direct sensory engagement became the means by which cultural and melodic filtering could disintegrate and give way to sensory modes capable of perceiving the complexity of raw perceptual materials.

Exploring this distinction between representation and direct sensory engagement by way of contrast, a Pulsa contemporary similarly concerned with environment, The Us Company (more commonly known as USCO), infused their installations and performances with psychedelic imagery. Take, for example, USCO's 1966 show at the Riverside Museum in New York City, which members of Pulsa attended. Art historian Michel Oren describes many rooms exploding with depictions of the Buddha, Hindu gods and goddesses, Native American figures, tie-dye fabrics, and messages set in art nouveau typography.[25] Much like Pulsa, USCO felt that "it [was] important to disregard content and regard effect," and that the creation of art should be primarily concerned with expanding human consciousness.[26] Nevertheless, USCO still sought representational modes of affecting perception. With the Riverside show, the group believed that overwhelming the senses through content overload would prepare viewers to enter a more meditative state "where some kind of transcendental content becomes possible."[27] Though Pulsa held similar interests in Eastern spirituality, what they termed "Pre-Columbian societies," meditation, and LSD, they rejected the use of images with specific cultural weight to bombard the representational faculties of cognition. Rather, Pulsa employed the analogues of perception—light and sound—to directly access the pre-rational faculties of neurological processing; the resulting experience was not intended to overload the viewer with abstracted stimuli. This more

sober style still often induced a meditative or trance-like state in witnesses, but the lack of imitative, representational content was intended to break down the filters through which humans approach reality. If sensation was believed to be the primary mode through which people access the fundamental complexity of the world around them, then Pulsa invited participants to ritualistically deprogram their thought processes in order to free themselves from increasingly antiquated cultural sensibilities that block access to universal truths.

Writing about *Project Argus* for the *New Haven Journal-Courier*, staff reporter William Betsch recalls "Lights you could hear, plastic that groaned, retinal after-images that eventually put your mind in a boat to float downstream."[28] Though Pulsa's work directly engaged sensuous human faculties, the group did not aim to provide pure spectacle or perceptual stimulation for its own sake. Rather, through activating the overlapping space between light and sound, these installations added dimensions to the sensory experience that challenged, rather than entertained, the viewers' perceptual experience of reality. Recall, for instance, that in *Program 3* audio wires were affixed to the fluorescent tubes in the room so that sound signals would determine the brightness. In a sense, this technique caused audiences to *see sound*. We can also turn to *Project Argus* as another instance of creating interstitial spaces between objects of perception. This show saw the inclusion of Mylar sheets into the Pulsa repertoire, adding another element for the "translation of light into illusory secondary spaces" through the material's reflective capabilities.[29] Electrostatic speakers adhered to the sheets also elicited a dynamic movement effect in the material. The synthesized soundscape did not just enter into the participants' perceptual field as sound, but was also translated into spatial movement and light (reflected off the moving Mylar) so that, as the reporter for the *New Haven Journal-Courier* described, plastic groaned and lights could be heard. This practice of conveying light through sound and vice versa

holds strong psychedelic resonances. As members of Pulsa experienced the overlapping of perceptual materials occasioned by psychoactive substances, so too did the environments they organized become tools for exploring the overlap between light, sound, space, and movement. It is this expansion of the limits of perceptual thresholds, through psychedelics or light and sound environments, that, in Pulsa's view, reoriented the human sensorium toward an increasingly electronic world.

Embodiment

If, according to Pulsa and other environmental artists of the period, the path to an expanded consciousness lies in a direct appeal to the senses, how does perception fit within the ontological category of "the body"? How did Pulsa endeavor to rechart the Cartesian duality dividing mind and body, subject and object? As an entry point, we can probe the origins of terms like "psychophysiology" and "physiological energies of perception" in Pulsa's writings and the neuroscientific implications therein.[30]

Pulsa's focus on the perceptual nature of the human-environment relationship corresponds to a renegotiation of the mind-body dichotomy necessitated by emerging cybernetic insights. Coinciding with the group's assertion that the world is accessible through the bodily affordances located in the eyes, ears, and hands, rather than through the brain's capacity for "reason," was a sympathy for the embodiment of the mind. Our neurological processes, cyberneticians held, are distributed throughout the organs of perception located in the fleshy body—and, increasingly, in the technological tools we employ.[31] This line of thought did not assert a wholly complete entity that collapsed the mind and the body; rather, ecological thinking held that the entire notion of an isolable being distinct from its environment was incorrect. The

human mind, its corporeal carrier, and the environment in which it is suffused are situated along a networked continuum where each exchanges and responds to feedback from the others. The senses activated in installations like *Program 3* and *Project Argus* are therefore not strictly localized within the confines of the body; rather, we can follow the systems view to which Pulsa subscribed and consider the senses as extensions of the body that receive input from the world around it. For example, Warren Brodey, writing in a 1972 issue of *Radical Software*, discusses the flow of energy between human and environment in terms of "biologically optimizing systems" in which one might "loop again the behavior of that which is outside himself, and go back and reconsider what was outside himself in terms of his behavior, and recycle his own behavior through himself altering it in such a way so as to maintain survival, or to evolve survival so as to relate to the external world."[32] In this cybernetic model, the sensations that motivate behavior occur "outside" the body. Perception, thus, is both an activity performed both within and outside the bounds of the corporeal; the body exists rather like an open, distributed system that intersects with those other systems outside it, all of which together form the totality of the environment. Following this extended view of the human, the subjective experience of an audience viewing a piece of art shifts; the evolutionary environment blurs or even dissolves the separation between art and audience. Here, the human steps into a cybernetic subjectivity wherein the processes of the mind are manifested externally through electronic means. The larger point expressed here, though, was that this expanded subjective mode would soon dominate our everyday consciousness in an electronic age.

In the modern parlance attached to immersive art, terms like "embodiment" and "interactivity" dominate conversation around the human experience of spatialized media technologies. In the 1960s and 70s, however, many artists and thinkers of the environment were

skeptical of such characterizations. Pulsa noted that interaction, in which human behavior affects the surrounding environment, implied "unfortunate overtones of Skinnerian control" that would elicit "base responses" from participants.[33] This apprehension surrounding "interaction" as either method or goal in environmental artistic practice comes out of a larger ontological claim that the human body and its surrounding environment are not clearly distinct categories. Interaction—an exchange between two beings or things—could imply a body unique to that which surrounds it, an assumption that stands in contradiction to a networked view of the world in which the environment exists as an extension of the human (and vice versa). The interactive impulse could also be read as an avenue by which humans could become controlled by their environment. As such, Pulsa had to distinguish between interaction as an incubator for uncontrollable biological response and as a complex feedback loop.

Time

Dovetailing with the renegotiation of the nature of perception and its attendant artistic implications were innovations in the temporal experience of art. A panel discussion precisely centered around these changing attitudes toward time took place in early 1969 at the New York Shakespeare Festival Theater as part of a series boasting the ambitiously broad title "Issues in Art."[34] This conversation featured leading conceptual artists Carl Andre and Douglas Huebler alongside Pulsa's own Michael Cain (a transcript of the discussion was edited by Lucy Lippard and published in the November 1969 issue of *Art International*). In the discussion, Cain expounds at length about his group's aim to "enrich time … on an experiential level" before taking a slight detour to describe how a certain mollusk species's behavioral response to the timing of tidal flows becomes encoded in their RNA. Cain draws from this curious example that

humans, too, possess physiologically ingrained rhythms of information that guide our experience of time in addition to the culturally manufactured markers of its passage. It is the task of the artist, then, to access this bodily clock in order to transform an audience's experience of the "conventional time structure." Here we hear echoes of Pulsa's rejection of referential constructs in favor of a more direct depiction of the reality made accessible through sensory experience. Returning again to Lucy Lippard's review of Pulsa's work in *Arts Canada*, we can find the critic referring to this temporality as guided by "personal body time" rather than "clock" time.[35] Due to the "psychophysiological" nature of these pieces, one's experience of time is rooted in the body's sensuous extensions such that the temporal experience becomes elastic, its passage quickening and slowing along with the frequency of ocular and sonic signals.[36]

Interestingly, the political tensions at play in this conversation on time are plainly evident in the text. The panel itself was organized for the benefit of The Student Mobilization Committee to End the War in Vietnam. Carl Andre, a member of the Art Workers Coalition anti-war activist group took a prompting question about the role of time in art as an opportunity to implore his fellow artists "to recognize their social power and social worth," while Huebler responded by stating that he did not know how to respond. Following Cain's allusion to the mollusk experiment, Andre criticized art like Pulsa's that mirrored the "electronic, computerized, dehumanized, strobe-lighted, nauseating, headache-producing world we're constantly subjected to." Instead, Andre yearned for an art of "timelessness" that assuages the overloading experience of modern life. Andre's vociferous anti-war dissent squares with his apprehension toward sensory bombardment through electronic means (or perceptual activation, if we take Pulsa's view) in that the instaneousness of the computerized world limits the capacity for long processes of reflection, the kind needed to avoid senseless war. As Pulsa's work evolved toward

programming electronic responses to real-time behavioral data and therefore became more detached from the calendar view of time, the group presaged a world dominated by what philosopher Paul Virilio calls a "global time that makes no reference to the local time of human history."[37] The temporal dimensions of Pulsa's environments elaborate their refiguration of the aesthetic experience by engaging the body's natural rhythms (as opposed to standard conventions that demarcate the passage of seconds and minutes), giving works like *Program 3* a sense of immediacy. The time-based nature of Pulsa's work, however, begged a crucial political question: do such experiences with electronic technologies that unfold in real time inhibit historical thinking? Do they turn our eyes toward an idealistic future while blinding us to the past?

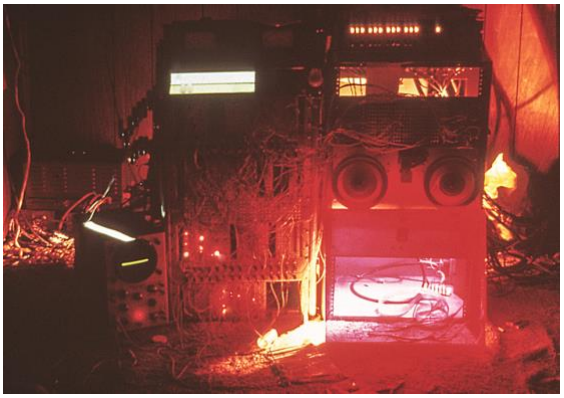
Sound

As part of a seminar Pulsa taught at Yale in the winter of 1968, the group brought together electronic music pioneers Steve Reich, Terry Riley, James Tenney, and Lamonte Young for a panel and demonstration on "music as physiological environment."[38] This event, which brought together the most prominent American voices in electronic and computer music of that time, constituted a significant event not just in Pulsa's career, but perhaps in the history of music more broadly. In fact, Edward Strickland marks this lecture as "the only time the four major figures of 1960s Minimalism were presented in tandem."[39] Music, as it often does, suffused the social world of Harmony Ranch, the commune where Pulsa transposed their aesthetic ideals onto their everyday lives. Maryanne Amacher, an experimental composer best known for her work in psychoacoustics, was a close collaborator of Pulsa who even lived at the Ranch for a time. Alvin Curran and Richard Teitelbaum of the world music collective Musica Elettronica Viva also spent time with Pulsa. Photos depicting scenes of life on the Pulsa commune heavily feature

instruments (both analog and digital) strewn about and residents engaged in music-making. David Rumsey recalls days-long jam sessions. In the summer of 1970, Pulsa also began experimenting with harnessing the energy of "brain waves" to control sound. These communal sessions were characterized by the group as "collaborative improvised sound sculptures," a descriptor that implies both a sense of ritual and spatiality.[40] These variegated interventions in experimental sound production illustrate that even though Pulsa was by no means a music group, their work both responded to and elaborated upon contemporary discourse on the nature of listening to and making noise. Daniel Belgrad has recently excavated the ramifications of systems thinking in sound, noting how musicians ranging from John Cage and Pauline Oliveros to Morton Subotnick and Brian Eno were interested in "the psychophysiological dynamics of interaction between a listener and a place."[41] I recognize three aesthetic projects shared between Pulsa and other artists working in sound: (1) eliminating or abstracting artistic control, (2) spatializing sound, and (3) evolving and enriching the human perceptual faculties.

Recall that the modes of collective work Pulsa advocated were attempts to move away from the imposition of artistic will, a lofty Enlightenment ideal that Pulsa rejected. This sentiment manifested itself in the group's thinking about sound, following a line of inquiry best expressed in the work of experimental composer John Cage. Most known for his composition *4'33"*, in which the performer sits in front of a piano for four minutes and thirty-three seconds without lifting her fingers to the keys, Cage became an inspiration for avant-garde and countercultural circles. Through much of Cage's career he struggled with the imposition of artistic control over sounds, leading him to devise various methods by which he could release music from the domination of his own hands and mind.[42] Pulsa transposed these ideas into the design of their Hybrid Analog-Digital Synthesizer. As I briefly touched upon in my discussion of

Project Argus, this machine, designed for use by non-technical artists, marks a significant yet largely unacknowledged advancement in the history of sound synthesis. At that time, the synthesizer world was dominated by two design philosophies; one proposed by Robert Moog on the East Coast, and another developed by Don Buchla on the West Coast.[43] The early Moog synths were essentially "switched on" versions of a traditional piano in that one operated the machine via a keyboard interface. In stark contrast, Don Buchla, directly inspired by John Cage, wanted to experiment with how a musician relates to his or her instrument. Some Buchla synths feature pressure-sensitive "keys," while the modular versions feature none at all, requiring the user to create sound via wire patches. At the heart of Buchla's philosophy was the same question that dogged Cage: how might one create music without musicians? Pulsa, in their contribution to the history of synthesizer development, followed Buchla's modular, keyboard-less interface; unlike Buchla, however, the Pulsa team did not differentiate between signal and control voltages.[44] In a report published in the journal *IEEE Spectrum*, Fuge and Kindlmann provide an example to illustrate this technical affordance: "a given voltage control oscillator operating at a low frequency might be used to modulate the frequency of another voltage control oscillator operating at a higher frequency."[45] In a Buchla synthesizer, the source and control are differentiated by two separate sets of patches in order to prevent the user from interchanging them.[46] This model, then, implies a level of inherent artistic control that Pulsa sought to wholly eliminate. By not differentiating between the source signal and the signal meant to modulate it, the Hybrid Analog-Digital Synthesizer released some of the imposition of artistic agency and allowed voltages to modify other voltages, moving closer to the Cageian ideal of letting sound speak for itself.




Figures 3 and 4. Two views of the Hybrid Analog-Digital Synthesizer.

Pulsa Group, "Image - Pulsa, Analogue digital synthesizer w General Automation Systems computer, punch paper tape reader in control trailer, Yale Golf Course, 1969" *Internet Archive*.

Pulsa Group, "Image - Pulsa, State of the Art voltage-controlled sine-wave generator, Original design given into public domain by publication in IEEE Spectrum 1968" *Internet Archive*.

How, then, did Pulsa craft the aural quality of their installations? If they were not interested in making music, what specific role did sound play in their environments? To answer these questions, we must consider the psychophysiological relationship, to borrow from Pulsa's vocabulary, between sound and space. The cadre of perceptual psychologists that emerged after World War II were similarly concerned with the spatialization of sound and its sensory effects. Chief among them was Erwin Straus, Busbea highlights; the neurologist-philosopher called attention to the phenomenological discrepancies between space perceived visually and space perceived aurally.[47] Unlike the objects of vision, sound travels through and fills space, directing the listener's attention to uncovering the location of its source. Straus's distinction portrays an unboundedness of sound, while also implying that vision, being better able to separate objects from their surroundings, seeks order and control. Marshall McLuhan extended this multidimensionality of the ear by introducing the aphorism "acoustic space" to describe how sound necessitates a more dynamic, embodied sensory response than the hierarchical, linear

modes of vision.[48] Pulsa channeled this attitude toward the spatiality of sound in their use of polyplanar speakers, arranged in a given space to envelop the audience in noises emanating from ever-changing sources. Reflecting on his group's early light and sound environments, David Rumsey describes each installation as an instrument, supporting Pulsa's—and the greater electronic music scene's—interest in constructing the illusion of space through sound.[49]

If the ear is by nature a more decentralized, less fixed avenue through which we come to know the world around us, then Pulsa wanted to be sure to eliminate any of the referential constructs that might detract from its inherent openness. Serge Tcherepnin, a friend of the group and a synthesizer architect himself, reportedly characterized the noises with which Pulsa created a sonic space as "light and sound, not song and dance."[50] He was referring to the fact that while the synthesizer did not really allow for the production of elaborate compositions, it served the agenda of activating perception. Similarly, Patrick Clancy recalls computer music forerunner Karlheinz Stockhausen pointing out that the circuits of the synthesizer served as its musical notation.[51] Rather than utilizing culturally-ingrained musical conventions that no longer served an increasingly electronic age, Pulsa opted to let voltages and digital logic determine the production of sound. The ideas about eliminating cultural filtering were thus hardwired into the integrated circuits of the hybrid analog-digital synthesizer, giving physical form to Pulsa's vision. The resulting soundscape appealed to a more bodily, sensuous aural experience, reinforcing a cybernetic subjectivity that dethroned the primacy of the visual in order to experiment with distributed, cyborgian modes of accessing the world.[52]

Totality

The experience of the environment, as the ecological thinkers of the 1960s and 70s understood it, engaged the perceiver at a sensory level, thereby blurring the boundaries between

subject and object. The location of "environment" is thus unstable, imprecise; it is neither within nor outside us. To provide something in the way of an answer to the problem of this elusiveness, the rhetoric of the perceptual field centered around the notion of totality. This view of the environment was not limited to the physical arrangements of the objects of perception, nor was it necessarily meant to evoke a natural expanse of land untouched by human intervention. Rather, the totalizing vision of the world captured the feedback-rich interplay between the human and everything that touches upon its experience of reality.

How did the environment become so unfathomably enormous in the first place? As civilization hurtled toward an anticipated Cybernetic Age, humans ceased to be tethered, literally and figuratively, to the surface of the Earth. Not only were people now capable of launching their bodies up to the moon, but technology increasingly liberated the senses from their corporeal confines in new ways. To draw from Marshall McLuhan's famous aphorism, electronic media had extended perception beyond its embodied forms,[32] expanding and refracting the vantage point from which we view and understand the world. Ecological thinkers suggested that we had become "the light bodies" for whom Friedrich Nietzche said the earth would become an entirely unfamiliar place.[54] With electronic technologies birthing a spatially and temporally distributed consciousness, the "context" of being in the world became incomprehensibly vast. Systems theoreticians, too, elaborated this totalizing view. Most significantly, many differentiated "systems" as subsets of the all-encompassing environment. Social philosopher Niklas Luhmann postulated that "systems define their own boundaries. They differentiate themselves and thereby constitute the environment as whatever lies outside the boundary."[55] Systems reflect their larger context while still maintaining what Luhmann called "operative closure." The environment, on

the other hand, subsumed all systems and was hence beyond the cognitive grasp of those situated within it.

How can an artist "create" or "build" environments if the environment is an active relationship, always already happening, between a perceiving body and the time and space it occupies? The totalizing view understands space as a facet of perceptual experience; the task of the artist therefore becomes not the mere construction of environments, but the arrangement of sensory energies. Coordinating perceptual phenomena would in theory facilitate, optimize, and enrich humanity's ability to navigate the vast expanse of the environment. As Gene Youngblood put in 1970, "to set in order the facts of experience is to reveal the relation between man and his circumambient universe with all its hidden potential."[56] Remember that Pulsa endeavored to dematerialize the art object, feeling called instead to experimentally organize perceptual phenomena to affect the human sensorium. Thus, the widely applied moniker "installation art" implies a sense of permanence and physicality that does not align with the Pulsa project. Viewing the environment as a total, ever-present experience, Pulsa did not "create" environments; rather, the group "formed a continuum with the existing environment so that environmental experience integrates."[57]

Coinciding with the discourse of totality was an emerging insight that the context in which all our anthropoid and natural systems are situated is largely outside our field of perception and knowledge. A paradox emerges at this juncture: the environment, in all its vast everything-ness, is mostly invisible, largely unknowable. Much as the physicists of the twentieth century dealt with the quandaries of relativity, ecological thinkers identified a problem of observation in the fact that our positionality within certain systems blinds us to complete awareness of the total environment. Charles Moore, the eccentric dean of Yale's School of

Architecture, made reference to this unknowability when he wrote: "The world that means the most to us … has for the past half century not been really very visible anyway."[58] Here, Moore draws on insights from Marshall McLuhan, who maintained that new environments, ushered in by technological change, are largely imperceptible. The shifting contexts "assume and impose a set of ground rules for the perceptual life that mostly elude recognition."[59] The spectre of an imminent computer age portended to further alienate humanity from its exceedingly incomprehensible environment. Designers, architects, ecologists, psychologists, and philosophers, therefore, took up the task of evolving the human perceptual apparatus for survival in the electric age.

Evolutionary Environments

Going back for a final trip through Pulsa's *Project Argus*, in which the group seemed to make the Brutalist beast that is Yale's Rudolph Building come alive with strobes and synth sounds, records of the event describe the visitors' amusement at the electric spectacle. Senior faculty could be seen waving their hands in the air, giggling like school children.[60] In the midst of all this fun, it may have been easy, without the proper context, to miss the true intention behind Pulsa's contribution to the show. In a statement given to the *New Haven Journal-Courier*, Michael Cain identified his group's ultimate purpose as "'[finding] ways to incorporate many other phenomena of the technological world into this sort of 'natural conception,' giving some kind of aesthetic quality to the interaction of man and machine to make men more aware of the planet on which they live.'"[61] The new awareness of a circumambient environment that Pulsa implemented through direct sensory engagement, temporal experience, and sound answered to a larger concern weighing heavy on the global consciousness: how emerging technologies would

alter the human psyche. As the spectre of automation threatened to eliminate jobs, visions of a robot takeover terrorized imaginations, and the menace of nuclear war portended to obliterate entire civilizations, artists informed by new definitions of the environment accounted for these fears by turning them into a problem of personal evolution. In order to survive in a world ruled by potentially ruinous technologies, Pulsa and other ecological artists of this moment believed that humans needed to alter the modalities by which they accessed the changing world around them, and the way to accomplish that imperative, they thought, was through experiences with aestheticized implementations of new technologies. To ventriloquize Buckminster Fuller, artists of the environment turned "weaponry into livingry."[62] As "design scientists," Pulsa did not create art for art's sake. Instead, their work took on an instrumental social purpose: evolving the human perceptual panoply to better navigate the dawning cybernetic world.

I use the term *evolutionary environment* to capture the social imperative for which environmental works like those of Pulsa were designed. In addition to enacting emerging insights about the ontology of "environment" from systems theory and perceptual psychology, these artist-researchers aimed to devise situations and interventions in which participants might, through contact with patterns of light and sound, achieve an expanded consciousness that would psychically prepare them for the new world ushered in by the computer. Current discourse around this art historical milieu employs terms ranging from immersive art and installation art to simply environmental art. While these capture a more general definition of the formal qualities of evolutionary environments, they do not evoke the larger purpose of art expressly aimed at affecting perception. The term "democratic surround," introduced by Fred Turner, runs parallel to the new conceptions of "environment" that I identify, but is oriented toward an earlier time period in which artists hoped to inculcate democratic personhood in participants where Pulsa and

their contemporaries sought to transcend politics.[63] Larry D. Busbea employs the framework "responsive environments" to describe works that implement a feedback loop between "viewer" and "environment."[64] While this denomination certainly describes Pulsa's later work in quasi-artificially intelligent environments, I hope that the evolutionary environment classification unites the entire body of Pulsa's work (as well as many of their interlocutors) under the umbrella of their social objective.

In order to contextualize Pulsa's evolutionary ambitions, I will once again turn to the network of the ecological pioneers who shaped the group's thinking. Of particular resonance with the evolutionary design ethos is Marshall McLuhan's concept of the anti-environment. Starting from the vision of an imperceptible total environment in which all systems are subsumed, McLuhan professes that "new technological environments need new art to provide a means of making us aware of the psychic and social consequences of the new environment."[65] The media theorist goes so far as to say that a great deal of all previous art has become so out of touch with the new conditions of a technologically mediated reality that they jeopardize our ability to understand our world. Gene Youngblood, too, impressed upon the imperative for artists to render visible truths about the environment humans inhabit: "the more information concerning the human condition that the artist is able to give us, the more energy we have with which to modify ourselves and grow in accord with the accelerating accelerations of the living present."[66] The 1970 *Software* exhibition at the Jewish Museum in New York, curated by Jack Burnham, espoused the software/hardware duality as a metaphor for describing the connections between human and environment.[67] In the catalog to the show, Burnham quotes Ted Nelson, the philosophizing pioneer of Internet architecture, who summarizes the dichotomy as "our bodies are hardware, our behavior software."[68] Following the metaphor to its logical end, software and

therefore our actions easily adapt in response to environmental feedback. Evolutionary environments, then, present an opportunity for participants to, as Burnham put it, "sense [their] responses when [they] perceive in a new way or interact with something or someone in an unusual situation."[69] Environmental artists like Pulsa, then, hoped to reprogram the human software and optimize it for a new use-case: the age of information. Pulsa defined the impetus for evolutionary environments as follows:

> Art showed potentiality for becoming more meaningful to our culture by reflecting the accumulating body of experiential information regarding complex human sensibilities being brought into existence and developed by technology. In particular, human perception has undergone evolution through exposure to a variety of technical phenomena.[70]

This concern with adaptation must also be situated within the geopolitical zeitgeist of its time; the atom bomb, war in Vietnam, social unrest on domestic shores, and degradation of the natural environment made the future seem bleak if not impossible. Responding to this existential anxiety, many artists devised strategies aimed at equipping people with the tools and information they needed to adapt to a world so radically different from the one beheld by the previous generation. The countercultural designers of evolutionary environments thus employed a rhetoric of survival to frame global existential crises. Rather than affecting change through the tried and untrue methods of politics, war, or social revolution, Pulsa and their fellow communards just wanted to *survive*. The light and sound situations they devised, then, were elevated to life-sustaining proportions. Pulsa's communal living practices also found footing within their survivalist project; at Harmony Ranch, the group (and their wives) grew their own food, sewed their own clothes, and traded with neighbors for the things they could not make on their own. In

other words, they prototyped new modes of living that located the solutions to global problems in individual lifestyle choices. Strategies of survival, architectural historian Felicity D. Scott notes, shift focus away from the functional political aspects of society and toward the *bios* of life, the mere imperative to keep oneself (and, by extension, all of humanity) alive.[71] The universalizing rhetoric of survival found a spokesperson in Buckminster Fuller, who preached that the solution to a planet-threatening crisis of "cosmic evolution" lay in "a design science initiative and technological revolution."[72] To train these technocratic architects of Spaceship Earth, Fuller devised "World Games" in which utopian dreamers (i.e., non-politicians) simulated strategies for distributing life-sustaining resources equally across the world.[73] The world depicted in Fuller's experiments hinged upon a benevolent view of technology; despite their capacity for mass destruction, Fuller asserted, the technical tools developed in the context of war could and should be reappropriated by "comprehensive anticipatory design scientists" to ensure the survival of humankind and the Earth it inhabits.

The formulation of the social implications attending emerging technologies as a perceptual, rather than political, problem placed the onus of evolution on the humans or "users" of technology rather on the underlying logics of the technologies themselves. As Pulsa itself evolved beyond the playground Yale provided them and into the urban public arena, their dreams of utopia sought actualization in the real world, broadcasting their socio-technical vision to a broader audience. The fundamental question becomes: do these environments allow people to become agents in their own perceptual self-evolution, or are they subject to an overloading of the senses that modulates their relationship to the world around them in ways they cannot control?

Chapter 2: "Being with the Machine": Publics and Politics

The privileged halls of Yale University may have afforded the young men of Pulsa a supportive cadre of mentors looking to accelerate experimentation in aesthetic implementations of technology, but the institution was also a barrier to accessing "the people" writ large, a prerequisite for the kind of social experimentation the group aimed to implement. If Pulsa wanted to lead a global shift in consciousness, they would need to address an audience far broader than the academic and art scene crowds, and do so in a format more radically "public" than the institutional platforms for the exhibition of art. This need for expansion ushered in Pulsa's turn to the urban environment and represents a marked shift in their evolving process of aesthetic engagement with the human sensorium. Whereas *Program 3* and *Project Argus* provided the group blank canvases on which to fabricate the dimensions of space with light, sound, Mylar, and other media, the city environment required them to manipulate an existing landscape. In exiting the halls of the academy, the instrumental social purposes that drove Pulsa's practice expanded to reflect the context of the city. How, then, would the goal of evolving perception scale up to involve an entire urban population? How did Pulsa alter the existing city infrastructure to better serve this process?

In this chapter I will expound upon the integration of evolutionary environments into the urban landscape and, more broadly, how systems thinking informed new approaches to city planning. This section focuses on two of Pulsa's installations, one mounted in the Boston Public Gardens and another held at New York City's Automation House, both of which encapsulate discrete facets of the sociotechnical vision Pulsa imagined would allow people to enter into dialogues with the systems that determined their cosmopolitan experiences. Ultimately I ask, and

gesture toward a possible explanation for, how the move away from physicality and toward information, away from governance and toward real time systems, renders the city as a system to be managed (or a game to be played) by the new cadre of artist-engineer-researchers that Pulsa modeled. Under this worldview, the relationship between human and reality, between subject and object, is dramatically reconfigured. It is quite remarkable how such a style or medium as minimal as that of Pulsa attempts to communicate such high-reaching goals for the reordering of the built environment and our own modes of perceiving reality. Such is the gusto of Pulsa and their contemporaries; like a written manifesto, the relative sobriety of content stands in sharp contrast to the capaciousness of its aims.

Switching on the Boston Public Garden

If you've ever wandered the grounds of the Boston Common and its adjoining Public Garden, you might have felt tinges of nostalgia or at least a moment of tranquility in response to the juxtaposition of this quaint 19th century park set against the backdrop of a major American metropolis. Visitors might careen down the Swan Boat Pond in pedal boats, feed families of ducklings, or admire the rich flora that colors the space. Imagine, then, the surprise of those passersby who visited the Public Garden on the nights from October 8 to 27, 1968, when this natural respite from the big, loud city became electrified by strobe lights submerged under the murky waters of the Swan Boat Pond and spatially-arranged speakers spitting out electronic noise.[1] This rupture in the normal rhythm of the Public Garden was the work of the Pulsa Group. Utilizing their Hybrid Digital-Analog Synthesizer, punched paper tape cards, and magnetic tape as a centralized control apparatus, the men of Pulsa programmed different versions of the light and sound event for each of the demonstration's twenty evenings. Following "digital" logic (in

the sense of a binary decision), the presence or absence of a punched hole would or would not switch open a gate that would then send an electric impulse to each of the fifty-five lights spread across the pond.[2] The sources of sound were culled from pre-recorded samplings of city noises (cars speeding down the highway, for example) as well as from live microphone pickups of the conversations of park-goers. The synthesizer remixed the sonic data of the city into electronic groans, washing the Garden in an aural cloud of amalgamated urban information.

Figures 5 and 6. Two views of the Boston Public Garden Demonstration.

Pulsa Group, "Image - Pulsa Environment Boston Public Garden 1968." *Internet Archive*.

Pulsa Group, "Image - Pulsa, Boston Demonstration, 55 Strobe lights, 55 polyplanar speakers, microphone, analogue-digital synthesizer, punch-paper tape reader, Boston Public Garden, 1969." *Internet Archive*.

A key difference between the Boston show and Pulsa's prior work lies in the definition and character of the audience. While visitors to Project Argus and especially the Orange Street loft performances had some pretext and expectation for the environment they saw, a majority of witnesses of the Boston Public Gardens installation had no prior warning or explanation for what they encountered in the park—they were simply going about their evening and happened upon an illuminated and sonically enhanced Swan Boat Pond. Rejecting the gallery system that rendered

art as an object to be owned, Pulsa strove to obliterate the subject-object relation altogether. Lucy Lippard observed that at the Public Garden performance, "the accidental 'audience' … serves to break down barriers between what one sees and what one is supposed to *look at*."[3] In essence, the Boston Public Garden performance functioned as art without audience—it invited an unwitting public into its folds, subsuming them within the "artwork" itself. The aesthetic experience was no longer confined to a strictly visual relationship between a viewer isolated from the art; rather, the experience of the thing we call art is rendered horizontally, with the human sensory apparatus serving as nodes in a feedback-enabled system alongside the computational control system. Perhaps this "system" replaces our notions of subjectivity altogether. In this convergence of subject and object, we might trace language that fits within contemporary discussions around immersive, interactive, or experiential art; increasingly, art is being refigured as an experience that incorporates the viewer into the piece itself. An animated figure projected onto a screen might mimic one's movements; objects of perception might disappear or shapeshift in response to haptic feedback; an AI robot might attempt to discern attributes about your identity using facial recognition. Do we "look at" art or does art "look at" us? In branding this kind of work as "public" in that it exists, physically at least, outside institutions, does art become more democratic and accessible, or does aesthetic immersion forge new pathways by which the logics of techne and their attending profit structures further ingratiate themselves in our lives?

In the case of the Boston Public Garden demonstration, the reflexive metacritique of art institutions runs parallel to a broader experiment in urban planning. In line with Pulsa's belief in art as social research rather than in a romanticized *l'art pour l'art*, the Boston project came into existence as part of a public policy study in the implementation of urban lighting. Stephen Carr,

an architect, planner and associate of prominent urban design theorist Kevin Lynch, had attended an early Pulsa exhibit and found the group had been tackling questions similar to those addressed in his own work. Carr partnered with Boston architecture firm Ashley/Meyer/Smith to carry out a study on "planning and controlling signs and lights for purposes of improving the flow of information in the city" for the Boston Redevelopment Authority and the U.S. Department of Housing and Development.[4] This policy experiment, dubbed and stylized as Signs/Lights/Boston, upheld cybernetic ideals of a society networked by open access to information, and believed that with the knowledge of how their city functioned on all levels, from how sewage pipes moved waste to the availability of various social programs, citizens would better understand their environment and, therefore, themselves. Specifically, Signs/Lights/Boston focused on how to achieve an optimal arrangement of urban lighting and informational signage to allow for the most efficient transmission of information to citizens. For utopian thinkers like Pulsa, the new modes of interacting with art and machines that they prototyped in their environments went beyond aesthetics; this cybernetic, extended, decorporealizing way of being in the electronic world became a matter of survival.

The Signs/Lights/Boston team captured extensive feedback from those park visitors who encountered Pulsa's piece. An estimated 6,000 individuals encountered the enhanced environment, and over 300 were surveyed by the organizers. Two-thirds of respondents reported favorable opinions about their experience. Those who enjoyed the demonstration described it as "dynamic" and "one of the most interesting things I've seen in a long time."[5] One viewer pointed out that "this particular work of art could produce far different reactions in people's minds than ordinary art such as paintings or statues." Another that "it's like God talking to us through electronics."[6] Attendees who were not as thrilled by the new art form called Pulsa's piece "anti-

nature," "boring," and "ugly."[7] *The Boston Globe* reported that an elderly man puffing on a pipe silently observed the light and sound display for a few beats before walking over to the comments chalkboard and simply writing: "Oh, No."[8] On a higher level, this practice of soliciting feedback from an audience witnessing an artistic demonstration in order to adapt the piece accordingly marks a departure from romantic notions of the complete art-object and the divinely-inspired genius creating independently from his audience. Rather, the recording of viewers' responses represents a further development of Pulsa's approach to creation as research. With Pulsa's orientation toward devising public situations that would instrumentally alter the relationship between the visitors and the environment they occupied, feedback became a crucial component of their design ethos. Certainly, from this perspective, art "looks at" its audience.

An ambitious crossover, the Boston Public Garden project provided Pulsa a sandbox in which to test their ideals of open collaboration between artists, the academy, government, and private industry, though the interests of each party often diverged. The Boston Parks Department Commissioner John D. Warner, whose department assisted in rigging the installation, told *The Boston Globe* that he hoped "the show [would] attract people with children, but not the lunatic fringe."[9] Though the communal living and psychedelic drug practices of Pulsa did not align with Commissioner Warner and the local government's vision for the electrified city, the two parties entered into an exchange of legitimacy which granted Boston an opportunity to support avant-garde art practices and acquire the resulting "coolness," while giving Pulsa the space to enact their aesthetic and social ideals.[10] In the eyes of the Signs/Lights/Boston study, the Public Garden installation served its urban planning agenda by creating a new "nighttime experience" and adding an additional use to the park space. Rather than highlighting the installation's aims to expand the consciousness of the urban populace, Carr and his team seem to have viewed the

Pulsa demonstration as an opportunity for the city to patronize the arts and invite industry donations. Pulsa's theoretical aims in this installation, however, reached far higher.

As hinted at in the opening to this chapter, the opportunity to devise more public-facing environments necessitated an expansion of Pulsa's theoretical aims beyond affecting individual perception and toward manipulating and enhancing the electronic phenomena already present in the urban landscape. In a report on the Public Garden demonstration, the group points out that the increasingly electrified experience of everyday life in the city had already "involved our culture in new areas of perception."[11] The city itself had already come to resemble the "anti-environments" Marshall McLuhan predicted would force seismic shifts in the modes by which we access and move about the world.[12] Pulsa felt that their task as artist-researchers, then, was to stage events of "audiovisual nonsynchrony" that would "make meaningful and pleasurable these experiences which are constantly present in our daily lives."[13] The current architecture of the city, Pulsa believed, fell dangerously out of pace with the unrelenting streams of raw perceptual data (literally the pulsating lights and sounds) provided by new media technologies like television, highways, billboards, and skyscrapers. The staticity of the built environment threatened to subject the helpless masses to the mechanizing forces of these accelerating innovations; therefore, the urban environment needed to be structurally imbued with the dynamism of emerging technologies in order to bridge the psychic and perceptual gaps between the machine and information ages. As Pulsa designed environments to evolve perception, the group recognized that the environments themselves must be equipped with the capacity to respond to change. In this double movement in the group's rhetoric around evolution, the *evolutionary environment* term I offer in Chapter 2 acquires a twin definition: not only do these

types of work target individual perception, but they are recursive in that they are endowed with the capacity for self-evolution.

City as System

Throughout the hot, muggy summer of 1970, a series of electrical brownouts plagued the American Northeast, periodically throwing patches of the New York City skyline into darkness.[14] The seemingly infinite stream of electricity revealed its limits as people turned up their air conditioning to accommodate the oppressive heat. Power failures like these captured the public imagination through much of the 1960s and 70s—in his recent book *Making Art Work*, Patrick McCray details how an earlier episode, dubbed the "Great Northeastern Blackout of 1965," prompted E.A.T. co-founder and Bell Labs engineer Billy Klüver to reflect on the ripples in public consciousness that this failure produced. "'The whole thing could have been an artist's idea,'" Klüver mused, "'to make us aware of something.'"[15] The ironic fact that only in a breakdown of infrastructure does an awareness of the systems that deliver resources, that indeed govern our lives, come about weighed heavily on the minds of Pulsa members as well. In their article for Gyorgy Kepes's compilation *Arts of the Environment*, the group makes specific mention of the 1970 brownouts to exemplify the "basic human alienation from the systems which make life in a given environment possible."[16] The inhabitants of a rapidly technologizing planet, Pulsa believed, were locked in an illusion of a pre-technological society perpetuated by the old guard of architects, artists, politicians, city planners, and more. In order to both reduce system failures and evolve the human psyche for survival in a cybernetic world, awareness of how information and resources move around the city needed to be built into the everyday urban experience.

How did the city come to be viewed as a system in the first place? In the outpouring of systems theoretical approaches into a wide variety of social and physical scientific disciplines, planners and architects noted that the complexity of the interlocking systems that comprise the urban environment required new models for understanding and effectively manipulating it. Chief among these cybernetic urbanists was Jay W. Forrester, a pioneering computer engineer and professor of system dynamics at MIT's Sloan School of Management. In *Urban Dynamics*, his definitive text on systems approaches to urban problem-solving, Forrester describes how a system as intricate as a city does not operate under the regime of a single, goal-oriented feedback cycle.[17] Rather, these many-layered structures arise from a multitude of intersecting negative and positive loops, with the latter taking on an openness that produces growth but, in doing so, becomes ever more complex. The standard model of "intuition"-driven political processes, Forrester asserted, could no longer account for and manage the dynamic contingencies of metropolises and the people who inhabit them. The systems thinker's proposal for the future of urban planning hinged upon computer models capable of testing the efficacy of proposed policies on the growth and stagnation of a particular locale. In the same year Forrester published *Urban Dynamics* (1969), cybernetician Gordon Pask penned an exploratory theory attempting to marry systems thinking and architecture.[18] In it, Pask characterizes the early history of designing the built environment as striving toward a "pure" architecture, taking as its bannister a narrow metalanguage centered around stability and style. The need for cosmopolitan, mass-use structures like railway stations and world exposition halls occasioned by the Industrial Age eventually eclipsed "pure" architecture. Pask notes that these new demands forced designers to see buildings "as a part of the ecosystem of a human society" for the first time. Architects were no longer confined to the construction of private homes or theaters accessible only to the elite;

they were now called upon to design the infrastructure of a city bursting at the seams, to endow the chaotic urban experience with physical form and order. However, these new architects lacked an appropriate metalanguage to contextualize their newfound positionality within the complexities of the human environment. Cybernetic principles, Pask believed, offered such a paradigm for designing within systems. Within the proposed cybernetic metalanguage, a new temporality emerges—rather than remaining static forms frozen in time, built environments must necessarily evolve alongside the dynamism of systems. A cybernetic architect "must be concerned with evolutionary properties; he cannot merely stand back and observe evolution as something that happens to his structures." Just as Forrester advocated a data-driven approach to modelling urban systems that could predict their growth and change, Pask argued for an evolutionary architecture capable of reacting to the shifting behavior of the environment and the beings and things that exist within it. As the flow of resources and information through the veins of the city became increasingly complex, the systems view of urbanism offered a lens through which architects and planners could think beyond the purist modalities of the built environment and toward a responsive, data-driven metalanguage.

The application of cybernetic principles to urban design fits within a greater renegotiation of city planning's goals and methods as a profession and academic discipline during the 1960s. In response to contemporary political events and their attending social protest movements, progressive designers of buildings and cities sought new frameworks that served the needs of the people rather than a social and spatial order that only served to reinforce oppressive power structures. Nowhere did this upheaval of tradition manifest itself more dramatically than at Yale, the home of Pulsa. Coinciding with the rejection of liberal modernism by students in the School of Art and Architecture that I described in Chapter 2, radical voices in Yale's Department of City

Planning also sought to dismantle a pedagogy that espoused a top-down approach to the built environment.[19] Calling for a design ethos in service of those who would occupy a given space rather than corporate and governmental powers, student-activists pushed the administration to develop experimental courses in advocacy planning and other community-centered approaches to design.[20] At the core of this pedagogical shift in the training of future city planners was the notion that the entire discipline, governed by bureaucratic thought, had become alienated from the real people it purported to serve. Echoes of these rallying cries for a more relevant city design paradigm can be heard within the cybernetic urbanism advanced by Forrester and Pask. The systems theoretical approach similarly rejected top-down, intuited policy programs and moved toward a citizen-informed model in touch with the real dynamics of the metropolis. But rather than "deprofessionalizing" the discipline by elevating the "planned-for" to stand on equal footing with the "planner" as many design radicals hoped to do, the cybernetic method of city planning sought to harness the real-time data exhaust of citizens and run them through computer models to make predictions and produce plans. Despite their fervent rejection of the hierarchical nature of politics, 1960s systems theorists reinforced the rigid divides between the planner and the planned-for, supplanting politicians with technically-informed experts as the designers of the built environment. Cybernetic urbanism, aligned with the New Left in the rejection of an authoritarian spatial order, refigured an emerging demand for citizen input as a process to be conducted not by conversation, collaboration, or community organizing, but by computers. In other words, behavioral data became a proxy for vocalized input.

Returning now to Pulsa's intervention in the Boston Public Garden, we can place the collective's venture toward an evolution of the urban landscape within this larger historical reconsideration of the traditional models of top-down design. Addressing a shared concern with a

built environment becoming further alienated from the experience of its inhabitants, Pulsa, like many protesting authoritarian spatial orders, sought a design protocol that would "redefine the urban environment in terms which clarify and support the reality of man's existence within the city."[21] Following the systems view advocated by Forrester and Pask, the group heralded information as the gateway to unlocking a mutualistic dialogue between citizens and their physical surroundings. To accomplish this goal, the city needed to become an interface between the individual and the abstract network of information that governs its functioning.

City as Interface

The demonstration in the Public Garden necessitated a technical advancement of Pulsa's evolving system for the control of programmed environments. Collaborating with MIT engineers, the team prepared punch paper tapes loaded with triggers to activate the logic gates of the Pusla Synthesizer which controlled the output devices in the pond.[22] As mentioned, live microphones and audio recorders picked up the sounds of the park and the city that surrounded it—crickets chirping, helicopters whirring overhead, frogs bellowing, cars honking, humans conversing. These bits of aural data filtered into the Hybrid Analog-Digital Synthesizer as voltages and were then relayed through any one of the fifty-five speaker channels, returning to the physical world as an abstraction of the city's sonic texture. Lucy Lippard's comment on Pulsa's work being informative of nothing but itself feels especially relevant here;[23] the ever-changing rate of lights blinking across the pond paired with the synthesized growls coming from the speakers subtly heightened the audience's awareness of this type of phenomena which already suffused their experience of the city. The Boston Public Garden piece reflected and amplified the new areas of perception that the electrified urban landscape had already thrust upon

the human sensorium. The problem here is that so much of this sensory data eludes our traditional faculties of perception. Troves of messages and stimuli pelt us as we walk down the street, drive on the highway, gaze into our screens; in the melee of this bombardment we lose our ability to make sense of all the input. The New Yorkers who remained oblivious to the very systems that powered their modern lives until the power failed illustrate how the presentation of the urban environment was largely illegible to its inhabitants, barring them from accessing information about how their surroundings, and therefore their own lives, functioned. Here, Pulsa's medium of the evolutionary environment represents an attempt to help humans adapt to an otherwise overwhelming slew of sensory data. However, the public work in the Boston Garden, being integrated into the information flow of the metropolis, comes at the problem of perception from a slightly different angle. Going beyond the explosion of subjectivity that transforms the aesthetic experience into a system looping between audience, media, and artist, the turn to public exhibitions sought to involve the entire urban population in this expansion of experience. Pulsa amalgamated the "natural" data of the city (crickets, frogs, humans) as well as the "artificial" (helicopters, cars) to create useful information, to separate the signal from the noise. These comprehensive designers integrated "new technological activities which characterize the functioning of the city with the city's physical infrastructure," thereby making "meaningful and pleasurable these experiences [of urban sounds and lights] which are constantly present in our daily lives."[24] The demonstration prototyped an entire urban architecture that serves this purpose of computing meaning from a perceptually incomprehensible sea of information.

The need to create cities that mediate a dialogue between people and the information that determines their existence became a chief vocation of urban theorist Kevin Lynch, professor of

urban design at MIT who is also listed as a consultant on the Sings/Lights/Boston report. Lynch introduced his seminal concepts of the environmental image and urban legibility in his 1960 book *The Image of the City*.[25] Inflected with the language of feedback and perceptual psychology, Lynch defines the environmental image as follows:

> Environmental images are the result of a two-way process between the observer and his environment. The environment suggests distinctions and relations, and the observer—with great adaptability and in the light of his own purposes—selects, organizes, and endows with meaning what he sees. The image so developed now limits and emphasizes what is seen, while the image itself is being tested against the filtered perceptual input in a constant interacting process.

In this view, the human enters into a mutualistic interaction with her surroundings rather than being rendered the subject of an imposing spatial regime. Lynch also presages the human-centered view of urban design that became the aim of pedagogical protest in the academy toward the end of the 1960s. In her analysis of Lynch's theories, Charissa Terranova teases out the "cyborgian" character of his urbanist language.[26] If the environmental image arises from a mutually constituting process between the perceiving subject and the environment subsuming them, then it follows that the perceiving body is ontologically defined in part by his or her sense of place. The sensory impressions projected by the city thus become an interface mediating the connection between, or merging of, man and machine. The notion of the environmental image implies that the raw data of the city lies beyond perception, that an image must be rendered in order for it to become comprehensible. Underpinning these considerations of the experience of urban life was an understanding of the overflowing streams of sensory stimuli that the current urban infrastructure struggled to contain; Lynch writes that "at every instance, there is more than

the eye can see, more than the ear can hear, a setting or view waiting to be explored."[27] This brings us to another tenet of Kevin Lynch's design philosophy: urban legibility. One's image of the city must also be legible, meaningful; the chaotic totality of the metropolis must be filtered through certain architectural and otherwise built interfaces that render one's experience of the city digestible.

Another character whose contributions greatly shaped this story of designing cities to mediate interactions between citizens and information is Nicholas Negroponte, leader of MIT's Architecture Machine Group. Design historian Molly Wright Steenson details Negroponte's promulgation of "architecture machines," or spatialized technologies with the capacity to respond to changing local phenomena.[28] These machines were to take on "an environmental scale," becoming the infrastructure that supports urban life. We can look to Steenson's account of the Architecture Machine Group's Media Room project to explore the notion of the city as an interface.[29] The experiment, in which a user reclines in an Eames chair outfitted with a joystick to control events on a giant screen in front of him, essentially functioned as a spatially distributed control device—an entire room as a computer. Here, Negroponte materializes ideas that resonate with Lynch's environmental image; a user's sense of place is figured as a function of information legibility. This "spatial sense of the data landscape" would, in theory, allow meaning to emerge from the urban noise, simultaneously expanding individual awareness of the total environment and promoting a harmonious relationship between machines and users. Exploding computing functions across an environment necessarily involves the human user on multiple levels of sensation; in Negroponte's Media Room, for example, a person operated the room-sized device tactilely with a joystick and received feedback in the form of visual and auditory cues. Thus, the interface allows one to sensorily embody the otherwise indecipherable logics of computation. In

the city-as-interface schema, opportunities for dialogue with computational machines exist on every surface, in every aspect of perceptual life; rather than "being with the machine," as Warren Brodey characterized his ideal techno-utopia, we would be *in* the machine.[30]

But what exactly is an interface? What does it do? An interface facilitates dialogue between two incompatible protocols, two entities speaking different languages. What gets lost in translation? In what ways does the interface conceal, blind, abstract? As Alexander Galloway explains in his theory of "the interface effect," the representative or translational function of the interface necessitates a "trauma" in the distillation or refraction of reality through the prisms of our screens, surfaces, structures.[31] As a result, "the truth of social life as a whole is increasingly incompatible with its own expression. Culture emerges from this incompatibility. The same goes for the interface: it emerges from this incompatibility; it is this incompatibility." If we are indeed "with the machine," we are only so through the semipermeable, distortive proxy of the interface. In applying Negroponte's architecture machines to urban design, the city becomes a proxy that renders the incomprehensibly complex systems that govern our lives (exchanges of capital, political representation, data extraction, energy distribution) somewhat legible, digestible. But what are the standards of legibility here? Whose language are we speaking? The information infrastructure remains a proprietary code. It may be necessary to abstract, translate, explain by metaphor these systems (technical, political, economic, etc.) in order for people to parse through them, to have some understanding of how the world works. But at what point do these systems become too vast, too global, too complex? The city, then, is also a stand-in for this array of systems, bursting at the seams of comprehension and management. Instead of more rigorously and politically negotiating this growth, and perhaps attempting to contain it, the rhetoric of the interface developed by cybernetic urbanists like Negroponte, Lynch, Kepes, and (to a less

impactful extent) Pulsa upholds an aestheticized abstraction of increasingly intricate systems as the key to making complexity meaningful. To be fair, I think this cast of characters would point out that my characterization ignores the element of dialogue, of mutualistic feedback mediated by an interface like the city or the keyboard. In their view, humans are not helpless against the logic of machines as long as these channels of man-machine communication remain open. Because this information infrastructure senses and adapts or responds to behavioral data, it becomes reified, seen as an objective representation of reality. But representation does not provide a one-to-one translation. Just as I argue that the systems-theoretical approach to urban planning uses data as a proxy for direct political action, I assert here that the notion of the city as an interface constitutes a flawed proxy for politics. After boiling away the glitter of techno-utopianism, the remaining core of this thought bubble is that a human can be accurately represented by quantifiable, behavioral data. In a dialogue between a human and a machine, the interface must translate human input into digital logic—ones and zeroes. In the reverse, machine code is represented in spatial, sensory metaphors such that it becomes legible to the human conversant. Neither party is capable of understanding the other's fundamental epistemology. The problem in the cybernetic urbanist mode of thought lies in assuming that the interface's powers of abstraction, in which human behavior is converted into digital language and machine language into digestible representations, provide an accurate enough representation of both man and machine such that the dialogue between the two entities can administer an entire society when scaled up to overlay the entire environment. In a material world in which every surface is interfaced, i.e. translating between two incompatible operating systems, formatting errors and data losses are bound to occur. Furthermore, in time, would we not pick up some of the machine's native language even through the filter of the interface? Would we not adapt

ourselves, in the spirit of cybernetic feedback, to accommodate the computer's protocol, make our behavior easier to parse for our machine friends? Here, the interface conditions our behavior to more easily adapt to that of our interlocutors. Extending this argument to the city-as-interface, cybernetic urbanity, over time, modulates our actions and desires to conform to the logics of the informational superstructures that define the city beyond the interfaces that rest atop the built environment.

In connecting this analysis of the interface to the work of Pulsa, a kink in the line emerges. Recall that, aesthetically, Pulsa aimed to dispose of representation in their work—"light and sound, not song and dance," as Serge Tcherpnin remarked. But later, the group writes about wanting to "present … technological systems architecturally to include aesthetic information which is functional but implies a new usefulness in relation to sensation and experience."[32] Echoing the aims of Negroponte, Lynch, and Kepes, Pulsa's public demonstrations turned the urban environment into a mediator between technical systems and the city's inhabitants, creating experiences for humans to sensorially perceive that data. How, then, did the group reconcile their creative practice against representation with their ideals about the city as an interface (or, to borrow from the title of their essay in *Arts of the Environment*, an artwork), which necessarily abstracts raw experience? If the interface filters data, then wouldn't Pulsa want to tear down those proxies and invite people to experience the raw totality of everything? Is there a divergence in Pulsa's practice and theory, the former focused on producing sufficiently informative situations of perceptual activity and the latter on a larger model for the cybernetic cities of the future?

One potential vector of reconciliation surfaces when considering how the Pulsa environments mediated an audience's experience with programmed stimuli. In shunning

representative forms, the group focused instead on eliciting responses located in the body—strobe lights created illusory secondary spaces, electronic thrums appeared to phase in and out with one's own pulse, an audience's sense of time became detached from the clock and reacquainted with bodily rhythms. To regurgitate Lucy Lippard's aphorism, the objects of perception in Pulsa's work are informative about themselves because they bypass cognitive processes of abstraction and aim directly at the body. If the machine's fundamental epistemology is binary code, then humanity's bedrock knowledge lies in sensation. By accessing what they take to be the most basic layer of human knowledge-making, Pulsa, taking cues from the efforts of people like Negroponte and Lynch, seeks to naturalize dialogue between humans and machines. In other words, by designing interfaces to facilitate such embodied interactions, they make interfaces more translucent. The interface mediating this feedback loop, along which light and sound travel directly into the sensory life of human bodies, recedes from view so that the interaction between man and machine seems more natural, more instinctual. The data that gets lost in osmosis between the actors on either side of the interface fades away, too. Though unavoidably ever-present, mediation wraps itself around the content, becoming indiscernible, pernicious. The medium becomes the message.[33]

Humanity through Machines

Thus far I have discussed what Pulsa's publicly situated environments *do* to its audience; here, I would like to more deeply consider *who* or *what* we might become in such situations. The further we extend our sensory receptors into multidimensional time-and-space via technology, the more unstable and embattled the ontological category of the human becomes. Our cyborgian realities rub up against Romantic ideals about the sanctity of the flesh, the position of the human

at the helm of progress. Posthumanist scholar N. Katherine Hayles points out that the Turing test, a game conceptualized as a litmus test for distinguishing between man and machine, exposes the crises in humanism merely by implying that a computer might pass as a human.[34] If one cannot rightly assume that their interlocutor is made of blood and bone rather than silicon and wire, then what becomes of our human identity? Will we have been supplanted by machines as the dominant species, subjected to an automated reality over which we have no control? Or will we come to embrace our human-computer hybridity and the release from the limits of the corporeal that it offers?

In the face of an uncertain future in which anything seemed possible, the innovators of emerging computational breakthroughs wove threads of mythology into their devices, providing users a depiction of the world these technologies would create. One public fear dogging these evangelists was automation and its effects on society and the individual. If machines entrenched themselves in every aspect of our lives, would we not become robotic ourselves, incapable of love, fellowfeeling, empathy? As both researchers and artists began to actualize previously hypothetical principles of artificial intelligence, one might expect the concerns over automation's effects on the human to exacerbate, exploding into a perilous existential dread. Not only would our actions be facilitated by machines, the spectre of artificial intelligence portended, but those machines would be processing, analyzing, responding to, altering, controlling our human behavior. To dam up any potential floods of automation anxiety, cybernetic thinkers adopted a framework for affirming our humanity *through*, rather than against, machines.[35]

Two such theorists wrestling through questions of computation's roboticizing effects on the people subjected to its logic were Warren Brodey and Nilo Lindgren, who together penned the influential essay "Human Enhancement through Evolutionary Technology" in 1967.[36]

Automated machines were indeed harmful to human development, Brodey and Lindgren affirmed; but the cure lay not in forever eliminating these technologies in a reprise of Luddism, but rather in endowing machines with *more* intelligence such that they could respond to and eventually predict our evolving goals, proclivities, and idiosyncrasies. Of the highest importance here is the element of responsiveness or adaptiveness; the authors note that traditional automated machines "follow fixed laws and, in managing them, *we* follow fixed laws."[37] In order to realize a "better mode of being with the machine,"[38] we must design a new breed of computational systems that are equipped with sensory receptors and the capacity to engage in dialogue with human users, allowing man and machine to enter into a symbiotic dance toward co-evolution. In this proposition lies an apparent paradox; preserving the essence of the human and enabling its continued evolution would require a more intimate, personalized relationship with artificially intelligent machines. To become more human meant becoming more cyborg.

Gyorgy Kepes, too, joined in the chorus of those articulating a techno-humanism in the introduction to *Arts of the Environment*. "The more powerful the devices we develop through our scientific technology," Kepes pontificates, "the more we are interconnected with each other, with our machines, with our environment, and with our own inner capacities."[39] Despite the techno-democratic idealism expressed in this statement, Kepes remained cognizant of the dangers attending a blind acceptance of technologies that had thus far brought war, environmental destruction, and social inequity. To reconcile his own optimism with concerns over the potential for an oppressive technocracy, Kepes located this misdirection in "a lack of moral intelligence."[40] The societal ills posed by technology were not the results of a faulty inherent logic but of the ways in which people used and perceived these devices. If creative thinkers with an ecological conscience could only reappropriate these tools and endow them with alternative

aesthetic meaning, people might finally embrace man-machine partnerships and realize their full potential, both as individuals and as an interconnected, peaceful society.

Automation House

How did this cybernetic take on humanism manifest in Pulsa's oeuvre? In what ways did the group prototype a utopian future of man-machine symbiosis? Perhaps the best example can be found by fast forwarding to a few years after the Boston Public Garden demonstration when Pulsa staged one of their last public environments at New York City's Automation House in April of 1971. Almost a decade earlier, prominent New York labor lawyer Theodore Kheel founded the American Foundation on Automation and Employment in response to his realization that "many of the labor-management disputes he was called on to mediate came down in essence to changes as a result of automation."[41] In 1967, Kheel and his foundation, which had partnered with Billy Klüver and the E.A.T. crew, endeavored to repurpose a condemned Upper East Side mansion for the creation of a multidimensional hub for industry, labor, management, and the arts. This initiative aimed to "'demonstrate the ability of new technologies to *help* individuals and solve problems,'" according to Kheel (italics original).[42] Here, Kheel's rhetoric echoes the brand of techno-humanism that refigures anxieties over the further integration of machines into human life as an opportunity for humankind to progress, to realize their full potential as technologically-extended beings.

For four nights in April of 1971, Pulsa was invited to adapt their system for controlling programmed environments to the multi-level building that contained Automation House.[43] By this time Pulsa had been experimenting in communication technologies for about a year, utilizing phone lines and closed-circuit television to establish audiovisual interfaces through which people

occupying disparate spaces could communicate. The result was a television sensorium in which audio and video inputs from one room would be transmitted as outputs in another room on a different floor, allowing occupants of one environment to communicate with (or spy on) the bodies inhabiting another location in the building. The exhibit also featured mirroring displays in which participants could see their movements projected onto a large screen, but delayed by six seconds. This lag created a "ghost trail" effect (similar to the reverberating effect induced by LSD, with which the group was intimately familiar) where the image frames bled into one another. The environment also featured the strobe lights and electronic sounds typical of a Pulsa installation. New to this project, however, was the inclusion of plants in the space. Pulsa affixed devices to measure electrical resistance on the leaves of the philodendron plants placed throughout the building. In a document detailing the outcomes of these experiments in a plant's ability to respond to a human actor, Pulsa describes how "The meters located [on] each plant give an immediate display of the plant's response to its environment; including your physical presence, but mainly your thoughts and emotions."[44] In addition to devising a platform on which humans might communicate with computers, Pulsa, in their activation of the Automation House site, allowed for nonverbal dialogue between humans and plants. Writing ecstatically about the possibilities for plant intelligence, Pulsa deepened their convictions about the decentralization of intelligence. In Automation House, cognition was not a process confined to the human brain; rather, Pulsa demonstrated an interconnected network of intelligence spread out across a community of biologic and artificial beings.

Figure 7. Automation House.

Pulsa Group, "Image - Automation House Pulsa T.V. Sensoriums Detail View Video Projectors and Plants, 1971." *Internet Archive*.

The environment Pulsa created within the structure of Automation House, which opened channels of communication between different floors, encapsulated the visions of a cybernetic society that Kheel's organization modeled. As an art exhibit, visitors might revel in the simulation of sharing space with people actually located in an entirely different room. As a prototype for governance in the information age, however, Pulsa's Automation House exhibition illustrates how information could flow freely between discrete units of management, situating the faculties of governance along a "horizontal" plane (well, technically a vertical one given the New York brownstone location).[45]

A broadsheet extolling the far-reaching aims of the Automation House project once again frames the problem of automated work eliminating jobs for people in terms of techno-humanism. The writer places humanity at a crossroads, waiting to see "whether technology will master the individual or whether it will bring out a new dimension of participation; whether the community will be destroyed through group conflict or whether it will find the means of resolving the disputes."[1] The implication buoying this forked path (one route promising peril, the other liberation) is one of path dependence—that technology broadly defined imperviously marches onward to its predestined end. Humans are not powerless in this scenario, the proponents of this worldview reassure; they have the agency to adapt their own perception to psychically embrace cohabitation with machines. The comprehensive designers among us also possess the power to envelop computers in interfaces that make those interspecies relationships more navigable, more mutually beneficial. Though for all their utopian imagination, nowhere in the techno-humanists' gospel does the possibility of altering the fundamental logics of certain structures (computation, capitalism, governance) come into play. What if the problems attached to automation (however rooted in speculation they may have been) resulted not from perceptual errors or a need for better interfaces, but rather from a more foundational flaw in the logics of the economic system that would dictate how automated work functioned? This point leads me back to the architectural philosophy of systems theory, which holds that designing the cities of the future would require architects to turn away from the spatial authoritarianism of Modernism and instead organize space with electricity and information. Much as the move to replace urban politics with algorithms removes the spaces where political debates occur, Automation House sought to

[1] Pulsa, *Automation House Exhibits 49 East 68th Street NYC 1971*.

answer anxieties around the impact of automation on labor by creating an environment in which the free flow of information would produce an emergent, natural order.

The exhibition at Automation House distilled a techno-humanist, utopian rhetoric into a prototype for a world in which computers, humans, and plants harmoniously coexist, aiding one another in their evolutionary trajectories along an arc of underdefined, yet unquestioningly positive, progress. An Eden for the new millennium, Pulsa's Automation House project presented visitors with a playground for ecstatic dialogue with humans, machines, plants, and the entire environment in which they stood. The whole experience seems to render physical Richard Brautigan's yearning 1967 poem "All Watched over by Machines of Loving Grace":

> I like to think (and
> the sooner the better!)
> of a cybernetic meadow
> where mammals and computers
> live together in mutually
> programming harmony
> like pure water
> touching clear sky.[46]

What gets lost in this hopeful story attempting to speak a life-sustaining cybernetic world into existence? If Automation House modeled a world in which communication technologies would replace politics, what new mutations of power and control emerge in its wake?

Real-Time Systems are the New Politics

In his collection of essays on the neo-avant-garde, *Great Western Salt Works*, Jack Burnham offers the idea of "real time systems" as those "which gather and process data from environments, in time to effect future events within those environments."[47] The critical importance of this mode of artistic experimentation for Burnham lies in its emphasis on "software" over "hardware," or the capacity of evolutionary environments to adapt to the dynamic conditions of a specific context and, in turn, provide new information about that context to participants. The light and sound environments explored in Chapter 2 lacked the sensory endowment that would enable their control systems to respond in real time to events occurring within the space. With the Boston Garden Demonstration and its inclusion of live sound pickup, Pulsa began approaching true real time systems. In that process, the "evolutionary environment" acquires a double-sided meaning: not only would these events occasion perceptual changes in the human participant, but the environment itself would mutate itself accordingly.

In projecting these real-time systems onto a vision for the city, artists and thinkers like Pulsa presaged an urban landscape that runs on data. Under this paradigm, information does not just support democracy, information *equals* democracy. Citizens might learn about employment opportunities, local history, or how the city's sewage system works by interfacing with information centers; decisions about the construction of new highways or the phasing out of social security benefits would be determined by computer modelling based on the current data picture of the metropolis; resources would be apportioned in accordance with information culled from the behavior of city-dwellers. The prototypical smart city defined by systems theorists in the 1960s and 70s takes inspiration not only from the proliferation of computational technologies, but also from a generalized antipathy towards institutional authority. But rather

than restore the power of self-government to the citizens themselves, cybernetic urbanists placed that power into their data, which citizens would have to unknowingly and constantly give up as they moved about the smart city. More than just an art historical term, the "real time system" also describes a cybernetic (a)political philosophy.

What does citizenship in this smart city look like? What becomes of the "public"? Following the digital logics that would administer such cybernetic metropolises, each individual's data would be aggregated to produce a portrait of the entire population. The language of systems theory mirrors this process by setting up a scale between the individual unit of the human and the totality of humanity. This same scale repeats itself in conceptions of the "totality" of the environment discussed in Chapter 2: the system is a perceivable subset of an imperceptible, totalizing whole. Likewise, the human system instantiates the overarching "oneness" of the entire species. However, just as the system-environment relationship is not an exchange between two completely isolable entities, there exists a feedback loop between the "individual" and the totality that incorporates the cleavages between the two. Warren Brodey, writing in *Radical Software*, characterizes this triadic relationship as follows: "All of our theory and governmentology has been that the individual is simply a member of the class called mass. Now, however, we start to move to what the interaction is between the individual and the mass in a way that takes in the context which is beyond either the individual or the mass, that is, that which is contained around that totality."[48] We can also look to Buckminster Fuller's "global village" as another representation of this theory of the public.[49] Within this utopian ideal, humans overcome their national, class, racial, and ethnic identities to unite as one under the wide umbrella of humanity—in Fuller's view, this is the only path that leads to the survival of our species. Ultimately, this line of thought arrives at what architectural historian Felicity Scott

describes as citizenship forged through a postnational network connected by communication.[50] The middle layers that traditionally demarcate and manage society—local government, state federalism, national borders—give way to a relationship of dizzying proportions. Joining in a wholesale rejection of top-down authority, systems theorists promulgated a new conception of the public free of the binds of nation and instead held together by communication technologies.

Once again we arrive at the question of mediation, of the interface. What mediates the individual's experience of the totality of the environment or of all humanity? For centuries, politics, government, and the proverbial "public square" provided a window through which people could reach beyond themselves and conduct the duties of public life. In addition to granting access to something larger than the single unit of person, this mediation necessarily contains an element of control. The interface controls our connection to that which lies beyond our flesh and thus shapes our movements, actions, decisions, thoughts, beliefs. The cybernetic redesign of mediation hoped to upend this hierarchy of interfaces by upholding the global communications network as the universal interface through which people could extend themselves farther than ever before. In their model, the interface would not be dictatorial, unchanging; it would respond to the real time trail of data generated by its own users.

Pulsa defines their own public project along these lines. In their "City as an Artwork" essay, the group defines their aims as "taking a given public context … where people come together and enhancing or expanding it."[51] In doing so, Pulsa explicitly attempts to "transcend the functional political aspects of human experience," opting instead for social organization on a higher plane of consciousness, to use Gordon Pask's locution.[52] This disengagement from the functional political aspects of public life reinforces the global village scale; traditional bureaucratic governance, much like unintelligent machines, roboticizes humans. To expand

society's collective consciousness, we would need to be reacquainted with the fullness of humanity, become capable of adopting a global lens. Pulsa's own model of group work process prototypes an entirely new mode of societal organization in line with this postnational totality of humankind. Recall that the collective shirked intergroup hierarchies and specialization and adopted a mode of networked individualism wherein all members acquired knowledge of every aspect of their projects. Though each person had undeniable strengths and areas of expertise, "engineers" were not privileged above "artists"; technical and creative decisions were made in tandem, one being inseparable from the other. In scaling up this model to the entire global population, the traditional notion of the individual shifts. While one certainly retains his or her own unique experiences and faculties, free and open access to information would, in theory, eliminate differences typically signified by nation, race, class, culture, education, etc. Everyone is an individual yet every individual is interchangeable.

To think through all these definitions of individualism together, both Pulsa's philosophy and the experience of a participant in one of their environments hinged upon a bifurcated notion of the individual. When viewed at the level of population, each human occupies his or her own node in an almost unfathomably large network of humanity. Upon zooming in on each particular node, however, the edges bleed. The individual is not a clearly defined, isolable being, but extends itself through technological devices and interactions with other systems and humans. The cybernetic mode of subjectivity that Pulsa advanced, then, does not just define any one person's extended relationship to reality, but also describes a kind of networked individualism wherein the lines connecting each node are not just mere conventions or notations, but rather reinforce the partial sublimation of the individual, the openness of the individual to the other systems it encounters.

Wandering further into this vision of a post-identity society of harmonious individualism, the economic and social boundaries and structures of the "public" also mutate. The new definition of individualism as at once singular and total (as in a global network of individuals) demanded that social spaces cater not to grand political projects, but to each unique person. As such, the design ethos of public space moved away from generalized mass-use and toward appeals to private interests. Charles Moore, the zany head of Yale's Architecture Department, embraces this personalization of public space in his infamous prelude to Postmodernism, "You Have to Pay for the Public Life."[53] In it, Moore heralds Disneyland as the new model of public-ness: "Disneyland, it appears, is enormously important and successful just because it recreates all the chances to respond to a public environment, which Los Angeles particularly no longer has." The catch, Moore admits, is that people must now pay an entry fee for such public spaces. In the rejection of the kinds of political processes which had heretofore guaranteed such spaces for communal gathering, this new mode of privately-owned public spaces emerges to fill the void. Moore embraces the blunt fact of waning public political participation; people no longer found meaning in such explicitly democratic activities. The real-time information centers sketched out by cybernetic urbanists start to look much like Disneyland in that they function as public spaces that cater to private interests and needs (though they would not require an admission fee). It operates on a view of the public as at once an assemblage of discrete units and a homogenous whole. In order to accomplish such universal personalization, the city would need to be endowed with a sensory apparatus that would monitor, record, and respond to the activity of its inhabitants. Thus emerges the smart city, a panoptic array of translucent interfaces that overlay the built environment, turning "space" into a multi-dimensional, sometimes invisible, and perpetually sensing apparatus. Such a philosophy for urban design relies upon the extended view

of the human and its relationship to the total network of humanity: rather than understanding population through the metrics of the community, family, or collective, the cybernetic individual, who occupies her own node while expanding outward across the entire network, becomes the fundamental unit of the smart city.

Chapter 3: Complexity and the Problem of the Observer

The arrangements of light-and-sound in the loft on Orange Street, the electric transformation of the Paul Rudolph building, and the Boston Public Garden experiment all invited participants to commune with technologically-produced phenomena that would, in theory, disrupt their rigid, constructed modes of accessing the world. This process, though, was a unidirectional one; the control apparatus possessed no avenue for having its processes altered by its human audience. The hot microphones placed throughout the Public Garden listened in on the sonic data populating the park, but this information was simply regurgitated back into the world; there were no mechanisms of logic that sought to interpret and make changes based on the data it culled. In order to inch closer toward the techno-humanistic ideal of conversational, mutualistic interactions between people and machines, Pulsa's range of computational capabilities needed to expand to include two-way feedback. The control system would need to sense the behavior of humans in a space, apply digital logic to that data, and produce outputs accordingly. Attending this move toward artificially intelligent environments, however, were implications of control by semi-sentient computers incessantly seeking to capture data. Just as the cybernetic thinkers I introduced in Chapter 2 contended with fears over automation, Pulsa needed to design both systems and rhetorics for mitigating the capacity for their environments to condition and control participants' behavior.

This final chapter examines Pulsa's response to the issue of control, and the tendency for that solution to open up new matrices of power embedded into the digital logic of computation. Here, I wrestle with the ultimate question driving my inquiry into the work of Pulsa: where does control mutate and emerge in evolutionary environments designed to expand consciousness and liberate perception? Which strategies did the Pulsa group employ to work around the problematic

nature of their own position as artists or system designers? I begin by analyzing perhaps the most significant point of inflection in the group's short career—their contribution to the Museum of Modern Art's *Spaces* exhibition in late 1969. I then explicate the larger discourses around the problem of control in systems theory while also delving into the second order turn in cybernetic thought and its understanding of complexity. Finally, I extend my analysis of control to the last phase of Pulsa's work which dealt with communication. In deploying interfaces to mediate communication between people across space and in real time, Pulsa prototyped a kind of politics without politics, in which a transnational network of information would order and structure society.

Spaces

At the end of 1969, Jennifer Licht, a young curator at the Museum of Modern Art in New York, pitched an exhibition of ephemeral, site-specific environmental works that would push the boundaries of the museum's definition of art.[1] Licht, who specialized in contemporary painting and sculpture, had served as the Assistant Curator under Pontus Hultén for the MoMA's landmark 1968 art and technology exhibit *The Machine as Seen at the End of the Mechanical Age*.[2] Building off that show's display of artists dealing with the spectre of an automated world, this new exhibition, dubbed *Spaces*, would deal more directly with the construction of time-based environments through non-object means. In her introduction to the *Spaces* catalog, Licht writes that "the human presence and perception of the spatial context have become materials of art."[3] Licht's show, art historian Julie H. Reiss notes, marked the Museum of Modern Art's first exhibition of non-object works installed on site.[4] Reiss also points out that the decision to pursue such an experimental exhibition was borne out of political pressure from the artistic community,

which had begun challenging the gallery system and the idea of art as an object. Licht pitched *Spaces* to the museum trustees as an avenue through which the MoMA could function outside the market system as a truly *public* institution by showing ephemeral works that could not be bought or sold but instead required that people experience the piece for a finite period of time.

The all-white, all-male roster of exhibiting artists included Michael Asher, Larry Bell, Dan Flavin, Robert Morris, Franz Erhard Walther, and Pulsa (the only artists' collective represented).[5] Pulsa was invited to take over the Sculpture Garden, a somewhat cumbersome outdoor patio area. The group installed sixty strobe lights and about as many polyplanar speakers along a loose east-west plane, and twelve directional microphones took in the sounds of the city and the voices of visitors as inputs to the control system.[6] The MoMA installation also saw Pulsa make use of twenty-seven infrared heaters as output channels controlled by the central computer. Two closed-circuit television cameras and cadmium sulfide photoresistors mounted in the upper floors of the building overlooking the garden sent a signal to the central computer in response to the density of people in various areas of the environment. The different nodes of interaction and response were centrally controlled by the group's General Automatic SPC-12 computer and determined by pre-programmed sequences stored on punch-tape cards. These multiple feedback loops (sound, light, heat) produced what Pulsa called "an ecology," a mesh of overlapping systems that together formed an environment. As a node within the network of this quasi artificially intelligent environment, a visitor would enter the snow-covered garden and notice the heat lamps and strobe lights placed among the bronze casts. As she began to move about, she might notice changes in the lights and sounds; after a while, she might correlate her bodily movements with the dynamics of the sensory stimuli, learning how to communicate, not through

words but through motion, with the control apparatus so as to elicit certain effects from the environment.

Figures 8 and 9. Views of the MoMA Sculpture Garden where Pulsa's entry into the *Spaces* exhibition was held.

Pulsa Group, "Image - Pulsa Installation for Spaces, MOMA, NYC, Photoelectric feedback loop controlling bank of infrared heaters, Sculpture Garden, 1970." *Internet Archive*.

Pulsa Group, "Image - Pulsa Installation for Spaces, MOMA, NYC, Photoelectric feedback loop controlling bank of infrared heaters, Sculpture Garden, 1970." *Internet Archive*.

The Sculpture Garden placement also afforded Pulsa an opportunity to manifest their ideals about "public" art. Since the Pulsa ecosystem took inputs from the entire urban landscape, the boundaries demarcating where the piece began and ended were blurry, if they existed at all. Thus, limiting access to the exhibit only to those who could afford an admission ticket would be antithetical to an experience not bounded by the traditional artistic assumptions of time and space. After extensive bargaining between the group, Jennifer Licht, and MoMA Director Bates Lowry, the Pulsa piece was made freely accessible to the public one night a week.[7]

Over the course of the *Spaces* experiment, however, the disjunct between Pulsa's lofty plans for a feedback-controlled environment and the limits of available computing technology proved to be an impassable roadblock. The CCTV cameras, which were mounted in the upper floors of the museum building, were meant to analyze the movement of bodies in the space and send that information to a time-sharing IBM 360 computer housed in a separate location.[8] That IBM computer was to be equipped with an early instance of a neural network, which would enable the control system to learn from its own operations.[9] The task of making the finicky SPC-12 computer communicate with the IBM 360 proved to be a major challenge; unfortunately, contact between the two operating systems was never established. The movements and voices of visitors in the garden were successfully translated into direct sonic, light, and temperature effects, but the malfunctioning of the neural network drew a dividing line among group members. Some, including Bill Crosby and Paul Fuge, saw the piece as an utter failure. Instead of having the IBM computer initiate recursive responses to the data collected by the sensing devices on the ground, the piece was limited to the SPC-12's pre-programmed punch tapes. Crosby in particular left the MoMA project disillusioned, as he spent the entire three-month exhibition attempting to connect the IBM computer to the central control unit. The other members of Pulsa, on the other hand, did not believe the system needed to work as designed because they viewed the entire piece as an experiment in process. Thinking of their art as performance, these group members cared less about the inner workings of the technical system (which was inherently limited by the technologies available at the time) and more about the phenomenological experience of the viewers. This faction was not as interested in developing functional technology products as it was in utilizing technology as a metaphor to illustrate ideas about what an electronically enhanced environment could look like. Though a neural network

would have further automated the environment's software, thereby diminishing the artist's imposition of control, the *Spaces* piece still achieved mutually responsive feedback between human participants and a computer system.

In spite of the technical elements that never properly worked, critics responded favorably to the phenomenal experience of seeing one's movements responded to by lights and sounds controlled by a computer. Writing for *Newsweek*, David Shirey proclaimed Pulsa's garden environment as "the most exciting" piece in the exhibition, and speculated that the show signaled "a new humanism [in art] as it incorporates man and his actions and reactions."[10] However, beyond the excitement surrounding the technical accomplishments of *Spaces* and its implications for the purpose of art, many critics raised doubts about the means and materials employed to achieve such grand technical spectacles like Pulsa's piece in the Sculpture Garden.

Industry

Technology as medium or material expands the scope of artistic production; typically, hardware and equipment must be acquired from a manufacturer. The tendrils of art extend beyond the Romantic picture of the lone genius tinkering in his studio, wrapping up an entire supply chain into the folds of creation. Pulsa believed that the role of the corporate sector in this system of art production should be passive; that industry should invest in art not in the hopes of receiving some return on investment, but for the sake of recognizing "the important creative force that art represents in society."[11] Within this paradigm, corporations are figured as benevolent patrons of the arts, modern-day Medicis. Contemporary scholars have documented the structures of open collaboration across institutions and disciplines during the Cold War; artists, too, became incorporated into this system.[12] This practice aligns with the cybernetic

renegotiation of the function of the artist as a "design scientist" rather than an elevated individual positioned outside and above the polis. Bringing the institutional fields of industry, art, and scientific research down to Earth and closer together would, in theory, warrant more direct social benefits. Recall also the collective anxieties attending the specter of an automated world in which computers would become increasingly inextricable from the daily lives of their human users. In addition to the strain of humanism promulgated by the cybernetic utopians to answer these concerns I discussed in Chapter 2, art served as another balm for such fears that resisted technological development. If technology could only be imbued with creative meaning, such theorists claimed, then the potential of computation for destruction would be ameliorated. And by integrating art into its structure, the business world would better serve social progress.[13] When it comes to corporate sponsorship of artistic production, Pulsa assumes a neutrality of intentions. Companies, the group insisted, should not demand specific results from their donations to artists, and nor should artists advance (or, conversely, explicitly thwart) the agendas of the companies whose products they used as media. Though they may have wanted to bring art and industry into closer contact, the intent was not to refigure art as a facile branding opportunity for corporations; there still existed a disciplinary and epistemological line between the two pursuits even within the model of open collaboration. This exchange would be purely transactional, and oriented toward "the public good."

For all this optimism, Pulsa's worldview is not one of blind acceptance of corporations as a necessarily positive or even politically neutral feature of civic life; in their formulation, corporations as figured in top-down liberal society often present a hindrance to the flourishing of human life. In the context of the city, private companies represent both an architectural and superstructural hoarding of resources. "Corporations," Pulsa wrote, "which represent small

minorities should not be allowed to monopolize resources; they should integrate their functions into the needs and desires of neighborhoods."[14] Pulsa's utopia would not wholly eliminate private corporations; rather, they would be better incorporated into the world game such that "the people [might] share in the benefits of local industry."[15]

But what happens when the companies from whom artists might receive material and institutional support simultaneously facilitate war? The overt involvement of private industry in the neo-avant-garde community garnered criticism from the Art Workers' Coalition, a conglomeration of activist-artists who opposed the museum world's capitulation to corporate interests and its lack of moral integrity with respect to the Vietnam War.[16] In a letter to *Spaces* contributor Dan Flavin, the AWC criticized the artist's acceptance of a lighting donation from General Electric, a company that had produced vast quantities of war materiel and whose labor force was on strike at the time.[17] It is worth noting that the Art Workers' Coalition included such participants as Lucy Lippard, Carl Andre, and Hans Haacke, critics and artists engaged in pursuits running parallel to Pulsa's work within the larger project of dematerializing the art object. In the group's list of "13 Demands" submitted to the Director of the MoMA, Bates Lowry, in early 1969, the inclusion of "experimental works requiring unique environmental conditions at locations outside the museum" became a central issue.[18] *Spaces,* which opened later that same year, responded precisely to this political demand which called upon the museum world to recognize the expansion of the institutional field of art production. The construction of six different room-scale environments tailored to specific locations proved a massive undertaking for the museum, which had hitherto been in the business of displaying premade art objects. Curator Jennifer Licht embraced this production challenge; in fact, she specifically called for pieces that "would make unaccustomed demands on our staff and resources."[19] Though

pursuing a similar project in expanding the scope and purpose of artistic experimentation and its institutional recognition, the AWC diverged with colleagues like Pulsa on the political implications of industry involvement in the creation of non-object works. The members of Pulsa, however, were not ignorant to the dual lives of their technical material as media for both art and war. Theirs was a program of direct reappropriation of the materials of war for creative means—Pulsa wanted to turn weaponry into "livingry."[20] Rather than fixating on the destruction wrought on a helpless polis, Pulsa stressed that the more dire issue lay in "converting from our wartime economy to the creative peacetime development of resources that might improve the level of life, the exploration of alternative lifestyles, and helping to establish global information systems."[21]

Though both camps marched in protests against the war in Vietnam, the Art Workers' Coalition and Pulsa diverged on the neutrality of implementing technologies of war in creative contexts. The question at the heart of the schism is whether reappropriation can ever be a subversive strategy, or whether technical artefacts can be politically neutral and agnostic toward use-context.[24] Did the use of General Electric fluorescent light bulbs in a light-and-sound display automatically sever the ties to the presence of those same bulbs in military camps in Vietnam? Where radical activists saw aesthetic implementations of technical materiel donated by companies with defense contracts as a legitimization of war, others like Pulsa understood the practice as an avenue by which such technologies, whose implementation in society at large seemed inevitable anyway, could be endowed with alternative, creative, and peaceful meanings.

Art critic Jack Burnham's theory of the "real time system" adds more detail to Pulsa's strategy of reappropriation. Recall that a real time system constitutes its own "metabolism," a self-stabilizing internal regulation process. Burnham locates the existence of such real time systems in military and commercial technologies: the SAGE Project produced a computer-based

air defense mechanism while SABRE allowed travel agents to reserve flights via computer.[22] While these applications represent for Burnham an "Orwellian" affront to humanist values, he emphasizes the need for artists to understand such technologies so that they can intervene in the techniques of information processing and redirect them toward the greater benefit of society. Just as techno-optimists viewed art as the salve that would endow the technologies of war with alternative aesthetic meaning, Burnham believed that artists should reprocess the real time systems deployed in military efforts, turning them into experiences aimed at the expansion of individual consciousnesses.

The local ethical quandaries afflicting the *Spaces* exhibition are symptomatic of a larger reckoning within the artistic community in regard to its interests in utilizing technology. For all the techno-optimism that engendered such praise and excitement around monumental exhibitions like *Cybernetic Serendipity* (held in 1968), by the time of the opening of *Spaces* in late 1969, political consciousness had shifted such that the merging of art with technologies also used in military exploits abroad was met with much wider skepticism and vitriol. Anne Collins Goodyear finds evidence of this sudden reversal in attitudes toward artistic implementations of technology in the specific event of the 1971 Los Angeles County Museum of Art (LACMA) project dubbed "Art and Technology."[25] This initiative, headed by curator Maurice Tuchman, paired artists with technical corporations that provided materials and a workspace for the artist, much in the vein of the E.A.T. matching model; the results of the collaboration would then be displayed at a LACMA exhibition. Of the seventy-six artists listed as participants (including Pulsa[26]), only twenty-three company-creator partnerships were fulfilled and only sixteen works were included in the final exhibition.[27] Despite the belief in the potential for open collaboration between industry and artists to bring about positive change, many participants in Tuchman's

program found their countercultural ethos irreconcilably at odds with the stuffy middle management structure of business. However, at a deeper level, the horrors of the Vietnam War and the complicity of American industry in human and environmental destruction reached a boiling point, eliciting further suspicion from (some) artists and the public at large. Collins Goodyear hints that the influence of the Vietnam War on art-technology experimentation may have incited the sudden end of this period of fervent optimism; indeed, the critical reception of *Spaces* affirms this hypothesis, but also signals that the waning of confidence invested in the juncture of art and technology may have begun percolating even earlier than 1971. The shifting tides of public perception of art-technology work can be traced within Pulsa's own body of work: while critical reviews of the 1968 Boston Public Garden demonstration raise no questions over the inclusion of technologies manufactured by companies with U.S. Department of Defense contracts, critiques of *Spaces*, held just over a year later, focused heavily on this exact issue. For instance, Dore Ashton praised the Pulsa piece for "its liveliness, its volatile stimuli," but found the show as a whole politically irrelevant due to the MoMA's covenant with the wealthy elite at the expense of a moral obligation to take action against the Vietnam War.[28] Similarly, Gregory Battcock called *Spaces* "probably the most brilliant, thoughtful and intelligent exhibition … during the last decade," but decried the fact that "nobody noticed that many of the contributors to the show (or their parent companies) engage in research and production activities that, either directly or indirectly, have benefited the Department of Defense and American genocide in Vietnam."[29] In the *New York Times*, Hilton Kramer expressed a skeptical outlook on technology, writing that the exhibition would have been "rather touching if the means of achieving them were not so egregiously mechanical and manipulative, so deeply implicated in the worst features of society as we know it."[30] Not only had the practice of corporate sponsorship of neo-avant-

garde work come under fire from activists like those involved in the Art Workers' Coalition, but skepticism had spread to the mainstream platforms for art criticism.

Pulsa sought to reorient the role of the artist towards engaging in socially instrumentable research and experimentation; yet their work came to be viewed by many as tone-deaf at best and at worst, affirmative of the military-industrial complex's genocidal actions. One might (and many did) find in the group's incorporation of technical materials donated by companies implicated in war an endorsement of corporate moral depravity; yet, in picking apart Pulsa's own descriptions of their (techno)utopia, the connection becomes more complicated. Private corporations are described in Pulsa's writings as a leech on the common good, but also as a necessary facet of supporting creative experimentation so long as that support remains disinterested, neutral. Set against the backdrop of festering skepticism toward aesthetic implementations of technologies also used in American military interventions in Vietnam, the MoMA *Spaces* show amounted to a tepid light show in the eyes of commentators and activists who were unimpressed with the exhibition's lack of critical reflexivity. In trying to sketch the true political implications of evolutionary environments, focusing on Pulsa's relationships with private corporations and the responses from activists and critics provides helpful context. To better capture whether Pulsa's use of war materiel affirmed their use in battle or redefined their meanings for positive social benefit, however, we need to peek under the hood and understand how the logics of computation interact with and influence the behavior of a human audience. How do the politics of the Pulsa control system align with or challenge the group's assumptions of institutional neutrality? Just as we once interrogated the meaning an artist hoped to communicate through the stroke of a brush or the curve of marble, the aesthetic implementation of technology and its requisite chain of production demand that we look for the meanings

embedded into resistors and breadboards and how the artists affirm or challenge them. Put simply, we need to uncover the politics embedded into the technologies the group employed in their work.

Figure 10. View of the photocell resistors mounted on the CCTV camera monitors, which sensed the movements of visitors in the *Spaces* environment.

Pulsa Group, "Image - Pulsa Installation for Spaces, MOMA, NYC, Control system - photoelectric sensors on monitor showing video surveillance of Sculpture Garden, 1970." *Internet Archive*.

Conditioning and Complexity

Move your hand, hear a series of clicks propagate across an array of speakers behind you. Walk around, unwittingly trigger a photocell sensor attached to a CCTV camera hidden in the upper floors of the building that flanks the garden, feel a burst of heat emanate from a lamp to

your right. These experiences made possible by Pulsa's control system relied on a computational protocol and a theory of human behavior that opposed one-to-one translations of actions into response. Instead, the movements of the participants were fed through Boolean logic gates so that the dynamics between action and response became more complex, initiating a triadic dialogue between human, machine, and environment. This ethics of complexity responds, once again, to the perceived potential for human-computer interaction to unleash a dehumanizing force. To reassert mutualism at the site of the interface, Pulsa proffered complexity as the combatant of behavioral conditioning. The evolutionary environment opens up a field replete with possibilities for action capable of triggering variable, surprising responses. Here, I intend to tell the story of how Pulsa reflexively dealt with the issue of control that dovetails virtually any interaction between humans and computers, but that figures prominently in situations where behavior trains an artificially sentient control system. I consider the group's proposed solution to this problem—instituting a complex field of potential sites of interaction—in terms of the relationship between the system and environment, which underwent significant reformulations in the work of second-order cybernetics like Francisco Varela and Humberto Maturana.[31] In these new systems theoretical programs, the relationship between the individual actor, the system of the evolutionary environment, and the totality of its broader milieu enter into a triad wherein the system maintains operational closure while remaining open to perturbations from the total context. Where, then, did Pulsa position itself within this triadic view? Did the group members view themselves as deistic orchestrators of a system who, after programming the control system, step back and assume a disinterested outside position, becoming benevolent observers? Or, was Pulsa's position more active, more engaged in capturing the behavior of participants? In this analysis I will not try to assign Pulsa to value-laden types of good or evil; rather, my attention is

focused on locating Pulsa's awareness of their own positionality as well as identifying ways in which their reformulation invites mutations of control. Here I will focus on four technical norms employed in the *Spaces* piece: Boolean logic, complexity, richness (vs. randomness), and the inside/outside binary.

Another wrinkle in my telling of Pulsa's story comes as a result of the gap between Pulsa's ambitions and the work they produced. The written plans for the *Spaces* piece, for instance, portray a much more complex system than the one visitors actually experienced in the museum. Considering that the group itself was internally divided over the conception of its own work as primarily an experiment in process or as the development of a fully functional technical artefact, how do we reconcile the group's aims with its material accomplishments and failures? In grappling with the group's orientation toward control and systems theory, I will remain rooted in the phenomenological experience of the final *Spaces* exhibit while broaching the theoretical or unrealized aspects of Pulsa's own thinking as it hints toward the logical ends of their beliefs about artificially intelligent technology. In other words, I take Pulsa's work at face-value while remaining critically engaged with their loftier aspirations.

Boolean

The Pulsa control system coordinated its output in accordance with logic gates that processed incoming information from stimuli on the ground. These channels operated according to Boolean logic, meaning that output followed an "and," "or," or "nor" decision-making protocol. By way of illustration, suppose you enter the Sculpture Garden, and your comment to your friend about the blustery temperature triggers a nearby microphone hidden from view. The electric impulse initiated by your voice would then pass through the Boolean gate, which, let's

assume, Pulsa had set to "and." As a result, a programmed light sequence would set off to your right *and* the live audio signal from the garden would be electronically remixed and panned across an array of speakers. The key conceptual piece of the Boolean design is the non-causal relationship between input and output. The control system would not directly respond to your complaint about the cold with the illumination of a single light; rather, your behavior entered into a network of decision trees that linked to an entire constellation of potential output scenarios that could be shifted around by altering the and/or/nor gates. An ecology of possible events, rather than a preordained program of causal call-and-response, thus emerges.

Importantly, Boolean logic also responds to a growing body of knowledge about neural networks. Warren S. McCulloch spearheaded discourse on the topic within cybernetic circles; the neurophysiologist believed the human nervous system could be modeled on the combination of all possible binary states that characterize neural activity.[32] Thought itself could be diagrammed as a logical succession of ones and zeroes, all and nothing. The computational logic of the Pusla control system, which operated on the on/off states of logic gates, mirrors McCulloch's neural network. Interestingly, McCulloch's view of neural processing moves away from the classical cybernetic conception of negative feedback. Rather than reaching outside itself to sense and respond to external stimuli, a neuron's activity derives more directly from its internal structure (the all-or-nothing of a binary state). The relationship between inside and outside is not a metaphysical one, as in Wiener's account; for McCulloch, neurons collapse form and content such that external phenomena become structurally integrated into their own logic sequences. A network thus becomes an autonomous entity. Here, as with Norbert Wiener's internal-external feedback schema, but to an even more radical degree, the boundary between subject and object, between *looker* and *looked at*, is reconfigured. One cannot be neatly extracted from the other

since they are structurally bound. As such, where the transcendent interplay between subject and external stimuli implies a relationship, the neural net model disintegrates that relationship into an immanent whole. While the former view implies a level of dependent control, McCulloch's theory stresses self-determination. Considering the logical sequence of the Pulsa environment, should we conceive of the interplay between participant and computer as an instance of negative feedback, or might we diagram the experience as a recursive network in the vein of McCulloch's model of neural processing? The simple rules governing Pulsa's control system—the Boolean gates—and the complexity that arises therein resonate with the structural theories of McCulloch. However, the selection of the and, or, and nor states was still a decision made according to the Pulsa group's own discretion. Though the outcomes of the performance in the Sculpture Garden were the results of spontaneous interactions between humans and the central computer, the systems designers nevertheless set the preconditions for such events to unfold. Pulsa's reflexive understanding of control, then, had to adopt a mode of thinking through the inevitability of control that could counter the charges of behavioral manipulations that attended artificially intelligent technologies.

Complexity

The rules that governed the Sculpture Garden environment were quite simple; a photocell sensor, for instance, might pick up the presence of a person in the space. A logic gate set to "or" dictates that if the photocell is triggered *or* a microphone catches sonic data (a bit of conversation or a gust of wind), a light on the east wall of the garden will initiate a pre-programmed patterning of flashes. Such basic algorithms produce complexity through their combination in a network of possible events. The simple avenues through which phenomena are processed guarantee an

almost infinite set of potential combinations.[33] Rather than allowing pre-determined plans, no matter how expansive, to define the bounds of the system, the emergence of complexity through simple rules instantiates a basic framework through which participant behavior determines the outcome in real time. The schema is open to the dynamics of everyday life, not confined to a top-down choreography or composition. Still, in line with second order cybernetic conceptions of the relationship between system and total environment, the Pulsa environment and its control apparatus retain a boundedness.[34] The computational rules that govern the Pulsa control apparatus interface with the chaos of the environment—the human visitors with their unpredictable movements, the changing weather patterns, the noise emanating from metropolitan activity beyond the Garden walls. As we saw in Chapter 3, interfaces function by bounding complexity; as such, we might understand the *Spaces* piece as what Mark Hansen calls a system-environment hybrid that remains structurally open to alterity while maintaining operational closure.[35] Following the classical Wienerian view of systems, the utter chaos of noise lends no information;[36] as such, the constraints afforded by a Boolean logic schema produce a "determinately structured complexity."[37] Under this conceptualization, informed by what we might now call second order cybernetic principles, the manual decisions involved in the design of evolutionary environments become a function of system definition, of differentiating between system and total environment without completely isolating one from the other. Pulsa would simply provide the set of initial rules from which a complex, improvisational series of events would emerge.

Richness

The emergence of infinite potential events breeds chaos, causing the given system to spiral into disorder. As such, constraints must be imposed to put a cap on chaos, to bound the entropic infinitude of possibility. The Boolean protocol represents one such instance of *complexity under constraint*; this schema resists the temptation to reduce complexity into one-to-one or top-down causality while maintaining boundaries or rules for the system. Pulsa opposes "richness" to "randomness" in order to describe the necessity of constraints in setting up fields of emergent possible actions.[38] In attempting to move away from the antipodes of direct input-output relationships and total randomness, Pulsa utilized logical structures, preprogrammed punch tapes, recorded sounds, and other control apparati to maintain operational closure while remaining structurally open to perturbations from the greater environment. With these frameworks for understanding control (Boolean logic, complexity, and richness), Pulsa adopts a language through which they themselves could understand and rationalize the inevitability of control in their role as systems designers. In fact, control becomes a *necessary* aspect of the evolutionary environment when considering the need to limit nature's unbounded chaos.

Inside/Outside

We thus arrive at the question of agency, of who imposes these constraints on a system, and on what basis the authority of the power to constrain is granted. The evolutionary environment obfuscates neat divisions between the perceptor and the object of its perception. But where do we position Pulsa as creators or designers of such environments? In assuming the role of system architect, Pulsa necessarily sets up the constraints and defines the limits of systems closure. They determine the avenues by which human participants might communicate with the

environment, and also dictate the responses such human activity would prompt. Responding to the problematic, unthought role of the observer in the post-war theories of systems, second order cybernetics identified the operation conducted by observers as one of distinction.[39] The observers or interpreters of systems demarcate the semi-porous bounds between the internal structure of a system and the external environment that provides a context. Does Pulsa, then, act as an observer marking out the space of a system through simple computational rules, or does the group assume a god-like position that grants them absolute power to determine the structure and function of the evolutionary environment? Certainly, Pulsa adopted a battery of strategies to mitigate whatever power the role of artist may have afforded them. Recall the mitigation of artistic control in the technical design of Pulsa's Hybrid Analog-Digital Synthesizer; by choosing not to distinguish between signal and control voltages, the group sought to lessen the imposition of the system designer's hand. Similarly, in trying (unsuccessfully) to incorporate a neural network into the *Spaces* piece, Pulsa sought to automate the process of control such that the environment would become completely self-regulatory—indeed, Pulsa strove to create art without artists.

If second-order cybernetics describes a move in which the "observer" is incorporated into the loops of the system, rather than granting said observer a privileged place above and outside, Pulsa adopted a slightly different program in which the observer or designer exercised as little power as possible. However, the transparency Pulsa strove to achieve in their work represents a sort of compromise with the second order call to accept the inevitability of the observer's role in defining the boundaries of a system. At the MoMA show, Licht and her team of museum staff gave the Pulsa men access to a glass-walled office to house the control system that stood just off the Sculpture Garden where the lights, speakers, and heat lamps were installed. This exhibition design choice granted the participants' eyes access to the central control mechanism—the Hybrid

Analog-Digital Synthesizer, the SPC-12 computer, the mess of wires and breadboards, and all the other components of technical infrastructure that worked in concert to sense phenomena and send out responses. This type of transparency was crucial to all of Pulsa's projects; with each work, as much as possible, the control apparatus was situated such that the technical infrastructure remained visible. If participants could *see* the computer, its guts unobstructed by opaque interfaces, then there would be nothing to hide, no way for control to persist, according to Pulsa. Rather than remaining outside the bounds of the system, the control system is incorporated, at least visually, into the context of the system; the human factors within that system are conscious of the second order observer. Yet, how much transparency is actually afforded in being able to look at the hardware of a Pulsa environment? To a general audience with limited knowledge of electrical engineering, seeing the potentiometers on the synthesizer and the photocell resistors on the CCTV monitors reveals nothing about how such technical nuts and bolts function within the greater system. The gesture of installing the control system in a glass house constitutes a performance of transparency meant to signal to audiences that they need not fear being controlled by the environment. Responding to this exact issue, critic Carter Ratcliff noted that though the central computing system was made visible so the audience could see the machinations by which phenomena were received and transmitted, "this process must be [believed] in. It's not to be felt."[40] Put differently, Pulsa relied on the trust of the viewers (or perhaps on their lack of technical knowledge) to execute their performance. The role of the system designer is then only semiotically or representationally incorporated into the relationship between system and environment.

Figure 11. The glass office that stored the Pulsa control system.

Pulsa Group. "Image - Pulsa Installation for Spaces, MOMA, NYC, Control system including analogue digital synthesizer, computer, real-time feedback loop, 1970." *Internet Archive*.

Evolutionary environments confront the issue of control by instituting a complex ecology of possible events. We might trace this ecological structure back through Pulsa's entire body of work. In opposition to the traditional, top-down models for urban planning, Pulsa and their fellow comprehensive design scientists prototyped adaptive technical apparati capable of responding to user behavior in real time. In their early shows in the New Haven loft, members of Pulsa experimented with non-representational patternings of light and sound that guided audiences into a more embodied mode of cognition that challenged their culturally ingrained thought schemas. The emphasis on direct sensory engagement in Pulsa's work signals a move away from the tyranny of representational thinking and toward emergent thought processes informed by an experience of the immediate sensory world. Though not systemically responsive

to the behavior of the bodies in the room, the *Program 3* environment simulated the ecological web of potential events—recall the subroutines of ionizing gasses and the microphones that picked up the sound of the reaction, or the ways in which the participants' bodies would fall into synchrony with the flashes of light. Running through and uniting the whole of Pulsa's body of work is the rejection of artistic control in favor of the design of systems that remain structurally open to instantaneous phenomena. Such openness institutes an *ecology of possible events* to counteract the capacity for spatialized, interactive media technologies to condition behavior. The question that remains is whether Pulsa's position relative to the system they designed can be thought of as that of a benevolent observer, or of a deterministic god; and, more broadly, whether a second order approach to cybernetics and the principles of self-organization it espouses offer a novel, potentially liberatory framework for understanding our own place within the world.

Experiments in Communication Technologies

After the monumental challenge posed by the MoMA show, the group shifted direction and reconstituted its membership. Bill Crosby, embittered by the technical failings of *Spaces* and the ensuing ideological differences, disaffiliated from Pulsa. Michael Cain and his wife, both deeply involved in Transcendental Meditation, set off for India. Kindlmann retained his position in the Yale Engineering department. The four remaining members, Rumsey, Fuge, Clancy, and Duesing, remained at Harmony Ranch for the spring and summer of 1970, where they delved into agriculture and land cultivation, hosted a revolving cast of eminent countercultural and avant-garde artists and musicians (including Serge Tcherepnin, Maryann Amacher, Richard Teitelbaum, Alvin Curran, and Max Neumann), created "collaborative improvised sound sculptures," and experimented with brain-wave music. Despite the frustrations at MoMA and the

subsequent fragmentation of the group's original membership, Pulsa's post-1970 work constituted perhaps the most prolific and informed period of their short existence. Lectures, more museum exhibitions, and teaching posts characterized the bulk of this period's activity. Pulsa also began to incorporate more video and television into their quiver of materials as they became increasingly interested in two-way communication and alternatives to mass media—the Automation House exhibit described in Chapter 3 epitomizes this latter phase of Pulsa's experimentation. The group held a teaching position at CalArts in both 1970 and 1971, where they experimented with both communication and Doppler radar, a technology that granted the control system a more granular view of human movement.[41] At the 8th Annual Avant-Garde Festival, an event orchestrated by experimental composer Charlotte Moorman at the Armory Building in New York, Pulsa blue-boxed a telephone line in order to establish a real-time audio and slow-scan video link between New York and CalArts in Los Angeles.[42]

These experiments in environmental-scale communication devices both expand and alter the concept of ecologies of possible events. While prior iterations of the Pulsa environment ostensibly facilitated an exchange between a machine and a human, the communication works brought humans into dialogue with other spatially dislocated humans. The control system thus served as the mediator of dialogue rather than the direct interlocutor. Such a scenario still retains flecks of complexity and richness; the technical infrastructure that provides the opportunity for communication across space does not impose a teleological plan for what kind of interaction can or should occur between participants, but nevertheless imposes constraints, through technical affordances, on the kind of conversation that emerges between the actor on either side of the screen.[43] Further, in creating a platform through which individuals might fling their voices across thousands of miles and re-present their bodies on spatially dislocated screens, Pulsa's

experiments in communication technologies reinvigorate their development of a cybernetic subjectivity. No longer were the faculties of the senses limited by biology; devices like portable video cameras and landlines (and later, the Internet) would allow humans to extend their sensory receptors across space and time.

This move toward an ecology of possible events, explored through both spaces endowed with proto-artificial intelligence and the multi-channel communication interfaces, elaborates Pulsa's earlier iterations of the evolutionary environment. While still aiming to expand consciousness through perceptual activation, this later phase in Pulsa's career more directly deals with the ability of the technical architecture *itself* to evolve in response to the sensations elicited by people and things in a given space. In doing so, Pulsa generated a framework through which they and their audiences might understand how control becomes a prerequisite for emergent spontaneity, rather than a vector by which computers dominate humans.

Figure 12. 5-way communication installation at CalArts, 1973.

Pulsa Group. "Image - Pulsa Five Way Video Communication Installation at Cal Arts, Valencia, CA, 1973." *Internet Archive*.

Conclusion

Journey to the Center of the Cybernetic Universe

Pulsa entered my life as a site for exploring how the kinds of "immersive" art experiences that are so ubiquitous today might function as an avenue by which the logics of technological artefacts, taking art as their vehicle, institute techno-capitalist logics into the human social realm and aesthetic experience. Such implementations of code and sensors, I also suspected, simply served as an aesthetic packaging, a marketing vessel for panoptic technologies that might also be used in more nefarious ways. I had spent a lot of time in creative communities deeply engaged in experimenting with the amorphous medium (can we even call it a medium? Perhaps a genre?) of immersive art—these projects and the people behind them were deeply intriguing, innovative, and fun, but I couldn't help but wonder: if the technical tools involved in this creative practice are also implicated in some of the worst features of our society, wouldn't these artworks become corrupted by the computational logics that allow for technology to be used as a weapon for targeting bodies and attention in the first place? By digging into the genealogy of artistic interventions in the proliferation of computation, artificial intelligence, and sensing machines, I hoped to uncover the true function, the final cause and effect, of the immersive environment and decide, once and for all, if such a creative endeavor can ever be liberatory, or whether it is doomed to accelerate a dawning technocratic world. My premonitions were, let's just say, skeptical at best.

Wading through the swaths of writings, images, plans, and ephemera that constitute the material legacy of Pulsa's ephemeral work plunged me into a time, place, and community of people grappling with a monumental shift in what it means to be a human. The looming phantom

of automation, the anxiety-inducing prospect of machines capable of thinking and behaving like a person, the rapidly approaching global communications network; these ontological conundrums all weave their way into the Pulsa archive, inflecting their material work with a dire sense of cosmic urgency. In the archive, I also encountered an oceanic network of architects, designers, theorists, evangelists, cynics, bards, revolutionaries, and reactionaries who proposed various means by which we might navigate the systems changes that lay on the horizon of technological progress. In many ways, these technical developments and their attendant collective existential crises mirror our current discourse around what new software and hardware will do to us.

Having circumnavigated the world of Pulsa and their compatriots, I now view my initial quandary as an improper lens through which to look at and make sense of the art of Pulsa. Returning to Marshall McLuhan's concept of the anti-environment, the value in works like the intervention in the Boston Public Garden or the communication environment installed in Automation House lies in their ability to effect awareness of the shifting, somewhat imperceptible dynamics of the present. At a time that demanded new models for understanding what the human is and how to be one, projects like that of Pulsa devised scenarios that confronted audiences with their need to understand themselves in an entirely new world. In this sense, the evolutionary environments of the 1960s and 1970s non-object, technologically-supported experimentation endeavored to return some agency to the human. Or, perhaps, in adopting a systems-theoretical understanding of the nested systems that constitute our interconnected individuality, they aimed to expand the definition of the human subject altogether.

Coda

In the first chapter of this project, I mapped the topography of Pulsa's aesthetic project, the goals driving the group's focus on the "environment," and what they meant by the term. The possibilities afforded by new technologies for devising situations through which audiences could encounter electrified events of programmed light and sound buoyed this period of aesthetic experimentation, and found perhaps unlikely support within the Yale Department of Art and Architecture, which Pulsa called home. Non-object, time-based media served as the canvas upon which the group enacted their mission to bridge the perceptual and psychic gaps between the Industrial and Information Ages. To do so, the men of Pulsa heralded direct sensory engagement, and not appeals to Enlightenment-era understandings of reason and representation, as the path by which human consciousness might evolve to thrive in a world fueled by information and machines. I have employed the term *evolutionary environments* to describe Pulsa's work; in doing so, I relate this group's project to the histories of environmental aesthetics undertaken by scholars like Busbea, Belgrad, Lee, Turner, and Terranova while specifically highlighting this group's unique marriage of form and ideology.

Pulsa should also be remembered for their technical accomplishments, which, in retrospect, serve as an important foundation for the kind of art-technology experimentation seen today. Their Hybrid Analog-Digital Synthesizer marks an important point in the development of electronic synthesis in its particular allegiance to the needs of the avant-garde artist over the traditional musician. Further, the group's later experimentation in audiovisual communication as an artistic medium finds its heirs in works like Sherrie Rabinowitz and Kit Galloway's *Hole in Space* (1980) and web-cam performances like *JenniCam* (1996-2003).[1]

Pulsa's reflexive understanding of their work positioned them as researchers exploring effective instances through which human consciousness could be expanded and altered. As such, their work and writings tend to take on a utopian glint, proffering visions of the world they hoped technology would unlock. When the group's work started to occupy urban public space, a cybernetic vision of the future city tagged along. In their understanding of information as the key to unlocking a greater awareness of the functions dictating the urban experience, Pulsa sketched out an early prototype of the "smart city" we've come to know (and fear) today. In this vision, governance and resource management are processes to be conducted by a cycle of feedback between computational infrastructures and human behavior. Here, building off architectural historian Felicity D. Scott's work on the politics of this cadre of comprehensive design scientists, I find that spaces for contestatory politics give way to automated data extraction and computational decision making. In the urban environment, Pulsa's reconfiguration of human subjectivity as a dynamic system of information rather than an isolable entity endowed with rational thought is extrapolated to characterize the entire urban population. The result is a form of biopower that figures the individual as a subset of the population, a sample whose behavior can be measured and used to initiate responses.

Finally, as Pulsa's work edged closer to something like artificial intelligence, the collective encountered the problem of their own positionality as the observer of environments designed to affect humans at the perceptual level. Here, my analysis touches on an issue largely absent from contemporary discussions of this art historical period—that of how this mode of human-computer interaction might institute control over participants, whether by the technical system itself or the people who designed it. Pulsa responded to the charge of behavioral control with a second order cybernetic understanding of complexity rendered in the computational logic

of Boolean gates. This formulation abstracted the designer's controlling hand by instituting an ecology of possible events that remained structurally open to the audience's dynamic and indeterminate behavior. Pulsa also addressed their own role in the environmental systems they devised by performing transparency; by leaving the central control apparatus visually accessible to participants, the group symbolically asserted their rejection of top-down control or malicious surveillance and manipulation. More than a metaphor for transparency, however, perhaps the display of the technologies controlling Pulsa's pieces symbolizes the unavoidable yet largely unthought implication of the systems observer.

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This study of Pulsa endeavors to provide an initial biography of the group while also interrogating how the evolutionary environment redefines traditional notions of subjectivity and the relationship between art, audience, and artist. Still, Pulsa demands further scholarship as we continue to unravel the intricately fascinating histories of art and technology. Unearthing the ways in which creative implementations of computing technologies give color to the social afterlives of such devices allows us to see beyond both uncritical technological positivism and fatalistic charges of dystopian hellscapes. The work of Pulsa, as an early example of physical spaces augmented by computational interfaces that is largely missing from current scholarship in the migration of cybernetics into art, calls on us to reflect on how we navigate the transition from a totally physical mode of being to an existence with one foot still rooted in the physical, and the other reaching toward the digital. In conceiving of a cybernetic subjectivity that moves beyond digital dualism and then enacts it through aesthetic experience, Pulsa actively created meeting points between humans and technologies, rather than accepting technology as something that happens to us. The emphasis on the smallest unit of human perception rather than more

collective, political modes of understanding how to *be with the machine*, however, glosses over the need to foster interdependent, communal layers of existence within the digital or posthuman realm. Picking up the motifs of and allusions to mythology that recur throughout Pulsa's writing, we might understand these evolutionary environments as opportunities for accessing new myths that help us orient ourselves in a changing world. Well-crafted words, for instance, do this when they allow us to access something we might already know or experience in a deeper or more meaningful way. The Pulsa environment, and the lineage of immersive art that extends into today's arena of art-technology experimentation, serves as an interface that allows us to reach beyond our embodied selves and experience the perceptual ecstasies of the posthuman condition.

Notes

Introduction

1. Stanford HAI. “About.”
2. Fuller, “A Comprehensive Anticipatory Design Science.”
3. See Galison, “The Ontology of the Enemy”; Edwards, *The Closed World*; and Martin, *The Organizational Complex*.
4. McCray, *Making Art Work.*
5. Turner, “The Corporation and the Counterculture.”
6. Blakinger, *Gyorgy Kepes*.
7. Turner, *From Counterculture to Cyberculture*.
8. Scott, “Vanguards.” See also Scott, *Architecture or Techno-utopia*.
9. For more on 1960s Minimalism, see: Krauss, *The Originality of the Avant-garde and Other Modernist Myths*; Strickland, *Minimalism: Origins*; and Lippard, *Six Years*.
10. Beck and Bishop, *Technocrats of the Imagination*.
11. McLuhan, *Understanding Media*, 148.
12. Throughout this thesis, I use the term “artificial intelligence” quite liberally. This catch-all buzzword tends to carry more mythic or cultural meanings than technical ones, which is precisely why I do not shy away from using it. For Pulsa, the hype-inflated, utopian implications of “artificial intelligence” far outweighed the nuts and bolts of the actual protocol, which may not have been artificial nor intelligent. That said, throughout this document, my references to “artificial intelligence” broadly denote a computational system capable of sensing and responding to user input.
13. Busbea, *The Responsive Environment*.

14. Steenson, *Architectural Intelligence*.
15. Belgrad, *The Culture of Feedback*.
16. Terranova, *Art as Organism*; Nisbet, *Ecologies, Environments, and Energy Systems*; Lee, *Chronophobia*; Oren, "USCO: 'Getting Out of Your Mind to Use Your Head.'"
17. See also: Maturana and Varela, *Autopoiesis and Cognition*; Varela, Thompson, and Rosch, *The Embodied Mind*; von Foerster, *Understanding Understanding*.
18. Wiener, *The Human Use of Human Beings*.
19. Hayles, *How We Became Posthuman*.
20. Clarke and Hansen, *Emergence and Embodiment*.
21. Pickering, *The Cybernetic Brain*.
22. Scott, *Architecture or Techno-Utopia*.
23. Barber, "American Dust."

Chapter 1

1. "Pulsa Project Planning, 1969-1970," M2540, Box 1, folder 5, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
2. Shirey, "Pulsa: Sound, Light and 7 Young Artists."
3. Burnham, *Great Western Salt Works*, 27–38.
4. Turner, "Romantic Automatism: Art, Technology, and Collaborative Labor in Cold War America."
5. Oren, "'Light as Truth': An Electronic/Art Historical 'Pocket' of the 1960's."

6. This approach to art as research finds heirs in movements like the Bauhaus and Russian Constructivism, which Pulsa cite as direct influences. See Gray, *The Russian Experiment in Art, 1863-1922*.
7. "Writing on Process + Art," M2540, Box 1, folder 6, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
8. Much of Conceptual Art at this time, too, was heavily concerned with "dematerializing the art object," as the project was characterized by Lucy Lippard in her seminal encyclopedia of artists working against the object view of art entitled *Six Years*.
9. Scott, *Architecture or Techno-Utopia*.
10. Moore, "Plug It in, Rameses, and See If It Lights up. Because We Aren't Going to Keep It Unless It Works."
11. Scott, "Vanguards," 3.
12. Blake, "Jerusalem ["And Did Those Feet in Ancient Time"]."
13. Tworkov, "The Yale Art School Light Show."
14. "Writing on Process + Art," M2540, Box 1, folder 6, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
15. See: Blau, "This Work Is Going Somewhere: Pedagogy and Politics at Yale in The Late 1960"; and Scott, "Vanguards."
16. Betsch, "Panoptics Fill Yale Gallery."
17. Hine and Coots, "Light, Sound, People Make 'Argus' Happen."
18. "Writing on Process + Art," M2540, Box 1, folder 6, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
19. Hine and Coots, "Light, Sound, People Make 'Argus' Happen."

20. Lippard, “Pulsa,” 59–60.
21. Boston Public Garden Show, October 1968, M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
22. Tworkov, “The Yale Art School Light Show.”
23. Ibid.
24. Lippard, “Pulsa,” 59–60.
25. Oren, “‘Light as Truth’: An Electronic/Art Historical ‘Pocket’ of the 1960s”; Oren, “USCO: ‘Getting Out of Your Mind to Use Your Head.’”
26. Oren, “USCO: ‘Getting Out of Your Mind to Use Your Head,’” 6.
27. Oren, “‘Light as Truth’: An Electronic/Art Historical ‘Pocket’ of the 1960s,” 12.
28. Betsch, “Panoptics Fill Yale Gallery.”
29. Tworkov, “The Yale Art School Light Show.”
30. This notion of “psychophysiology” builds off the work of scientists and technologists such as Marvin Minsky, Warren McCulloch, and Gregory Bateson. See also: Busbea, *The Responsive Environment*; Minsky, *The Society of Mind*.
31. Busbea, *The Responsive Environment*, 1–44.
32. Brodey, “Biotopology 1972.”
33. “Writing on Process + Art,” M2540, Box 1, folder 6, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
34. Lippard, “Time: A Panel Discussion.”
35. Lippard, “Pulsa,” 59–60.
36. Pulsa’s understanding of time, as Michael Cain mentions in the panel discussion, is also largely informed by their reading of George Kubler’s influential art historical treatise *The*

Shape of Time. It is worth noting that Kubler taught at Yale while the members of Pulsa were students there.

37. Virilio, *Cybernetics and Society*.
38. Though he was not present at the lecture, Philip Glass also had music featured in the evening's program (Glass was represented by Reich). See: Pulsa. "Pulsa Yale Seminar 1968."
39. Strickland, *Minimalism: Origins*, 210.
40. Oren, Michel, and Rumsey, David. "Michel Oren Interview with David Rumsey, 1989 May 15."
41. Belgrad, *The Culture of Feedback*, 113.
42. Turner, *The Democratic Surround*, 115–148.
43. Pinch and Trocco, *Analog Days*.
44. Kindlmann, "Sound Synthesis: A Flexible Modular Approach with Integrated Circuits."
45. Ibid., 508.
46. Pinch and Trocco, *Analog Days*.
47. Busbea, *The Responsive Environment*, 23–28.
48. Turner, *The Democratic Surround*, 115–148.
49. Oren, Michel, and Rumsey, David. "Michel Oren Interview with David Rumsey, 1989 May 15."
50. Ibid.
51. Oren, Michel, and Clancy, Patrick. "Michel Oren Interview with Patrick Clancy, 1988 November 7."

52. The group also cites their pilgrimages to Wesleyan University, where they visited ethnomusicologist Bob Brown, as particularly formative of their interest in non-object, ritualized experiences. Brown put together evenings of Indian musical performances, bearing the problematic name "Curry Concerts," in which guests could listen to and participate in the traditions of the invited artists. See: Oren, Michel, and Clancy, Patrick. "Michel Oren Interview with Patrick Clancy, 1988 November 7."
53. McLuhan, *Understanding Media*.
54. Nietzche, *Thus Spoke Zarathustra*.
55. Luhmann, *Ecological Communication*, 6.
56. Youngblood, *Expanded Cinema*, 64.
57. "Writing on Process + Art," M2540, Box 1, folder 6, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
58. Moore, "Plug It in, Rameses, and See If It Lights up. Because We Aren't Going to Keep It Unless It Works," 34.
59. McLuhan, "Art as Anti-Environment."
60. Betsch, "Panoptics Fill Yale Gallery."
61. "PULSA Pulsates: New Art Form Tried at Yale."
62. Fuller, *Critical Path*, 35.
63. Turner, *The Democratic Surround*, 115–148.
64. Busbea, *The Responsive Environment*.
65. McLuhan, "Art as Anti-Environment."
66. Youngblood, *Expanded Cinema*, 64.

67. Accounts of Pulsa's involvement in this exhibition are conflicting. Some members recall being asked to contribute a piece at the last minute, leading to an unsatisfying light-and-sound installation relegated to a back corner of the space. Patrick Clancy remembers being asked to curate the entire show, but the group elected to pass the opportunity onto their friend Jack Burnham. Apparently viewing Pulsa as a competitive threat, Burnham did not ask Pulsa to participate in the exhibition according to Clancy's telling of the story. The *Software* catalog makes no mention of Pulsa.
68. Burnham, "Notes on Art and Information Processing," 12.
69. Ibid.
70. "Pulsa Project Planning, 1969-1970," M2540, Box 1, folder 5, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
71. Scott, *Architecture or Techno-Utopia.*
72. Fuller, *Critical Path,* xviii.
73. Members of Pulsa participated in a World Game staged by Fuller himself at Yale in 1969. See: Fuller, Yale University, "World Gaming"; New Haven, Connecticut [1 of 2].

Chapter 2

1. "Boston Public Garden Show, October 1968," M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
2. Chandler, "Art in the Electric Age."
3. Lippard, "Pulsa."
4. Signs/Lights/Boston, *City Signs and Lights*.
5. Ibid.

6. Davis, “Hub Public Garden ‘Turns On.’”
7. Signs/Lights/Boston, *City Signs and Lights*.
8. Davis, “Hub Public Garden ‘Turns On.’”
9. Botwright, “Sound-Light Show for Public Garden.”
10. The term “exchange of legitimacy” comes from Max Weber’s theory of charismatic authority. See: Weber, Max. “The Three Types of Legitimate Rule,” translated by Hans Gerth, in Amitai Etzioni, editor, *Complex Organizations*, New York: Holt, Rinehart and Winston, 1961, p. 4.
11. “Boston Public Garden Show, October 1968,” M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
12. McLuhan, “Art as Anti-Environment.”
13. Boston Public Garden Show, October 1968, M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
14. “Blackouts and Brownouts.”
15. McCray, *Making Art Work*, 78.
16. Gyorgy Kepes published the *Vision + Value* book series, a wide-reaching project that brought together prominent voices from biology, psychology, social theory, architecture, and art to advance a new understanding of vision for the age of information technology. The seventh and final installment, published in 1972 and titled *Arts of the Environment*, features Pulsa’s essay, “The City as an Artwork.” See: Kepes, *Arts of the Environment*, 212.
17. Forrester, *Urban Dynamics*.
18. Pask, “The Architectural Relevance of Cybernetics.”

19. Blau, “This Work Is Going Somewhere.”
20. Goldstein, “Planning’s End?”
21. Kepes, *Arts of the Environment,* 210.
22. “Boston Public Garden Show, October 1968,” M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
23. Lippard, “Pulsa.”
24. Boston Public Garden Show, October 1968, M2540, Box 1, folder 17, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
25. Lynch, *The Image of the City*.
26. Terranova, *Art as Organism,* 149.
27. Lynch, *The Image of the City,* 1.
28. Negroponte, “Towards a Humanism through Machines.”
29. Steenson, *Architectural Intelligence,* 199–201.
30. Brodey and Lindgren, “Human Enhancement through Evolutionary Technology.”
31. Galloway, *The Interface Effect,* vii.
32. Kepes, *Arts of the Environment,* 221.
33. McLuhan, *Understanding Media*.
34. Hayles, *How We Became Posthuman*.
35. In his essay “Romantic Automatism: Art, Technology, and Collaborative Labor in Cold War America,” Fred Turner introduces the term “Romantic automatism” to similarly describe how the avant-garde leveraged automation as an avenue by which to reimagine artistic agency. My discussion here focuses less on how computation functioned as a component of art-making and more so on the effects of automation on the audience.

36. Brodey and Lindgren, “Human Enhancement through Evolutionary Technology.” Members of Pulsa cite this article as one of the most influential to their collective thinking.
37. Ibid.
38. Ibid.
39. Kepes, *Arts of the Environment*, 7.
40. Ibid.
41. “Automation House.”
42. Ibid.
43. Automation House exhibits 49 East 68th Street NYC, 1971, M2540, Box 1, folder 3, Pulsa records. Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
44. Miscellaneous documents, correspondence, notes etc., Pulsa records (M2540). Dept. of Special Collections and University Archives, Stanford Libraries, Stanford, Calif.
45. Scholar Kim West, drawing connections between Automation House and Vladimir Tatlin’s 1920 Monument to the Third International, writes that “Tatlin’s tower had been the model for a new kind of institution whose radical, technologically advanced architectural frame would support a multipurpose center for social assembly, political deliberation, and information dissemination.” Similarly, Automation House, and specifically Pulsa’s contribution, serves as a proof-of-concept for a hyperlocal hub of information circulation made accessible to the public through various interfaces. However, where Tatlin’s tower strove for a free praxis of self-determination, Automation House implies governance without politics. Though “democratic” in the sense that it

enabled the public to freely access information, Automation House's political orientation aligned with a techno-humanist perspective on labor that figured anxieties over the rise of technologies as a psychic rather than political problem. See: West, "Autonomy and Automation."

46. Barber, "American Dust."
47. Burnham, "Real Time Systems."
48. Brodey, "Biotopology 1972."
49. Fuller, *Critical Path*.
50. Scott, *Architecture or Techno-Utopia*.
51. Kepes, *Arts of the Environment,* 212.
52. Pask, "The Architectural Relevance of Cybernetics."
53. Moore, *You Have to Pay for the Public Life: Selected Essays of Charles W. Moore.*

Chapter 3

1. Licht, *Spaces*.
2. Hultén, *The Machine, as Seen at the End of the Mechanical Age*.
3. Licht, *Spaces*.
4. Reiss, *From Margin to Center*.
5. Licht, *Spaces*.
6. Ibid.
7. Oren, Michel, and Clancy, Patrick. "Michel Oren Interview with Patrick Clancy, 1988 November 7."
8. Oren and Crosby, Michel Oren Interview with William Crosby, 1989 February 24.

9. The lack of documentation illustrating precise plans for this “neural network” makes it difficult to understand precisely how this recursion would actually work. See Oren, Michel, and Clancy, Patrick. “Michel Oren Interview with Patrick Clancy, 1988 November 7.”
10. Shirey, “Art in Space.”
11. Kepes, *Arts of the Environment,* 219.
12. See also: Lee, *Think Tank Aesthetics*; Martin, *The Organizational Complex*; McCray, *Making Art Work*; and Turner, “The Corporation and the Counterculture.”
13. See also: Turner, “The Arts at Facebook: An Aesthetic Infrastructure for Surveillance Capitalism.”
14. Kepes, *Arts of the Environment,* 213.
15. Ibid.
16. See also: Bryan-Wilson, *Art Workers*.
17. Glucek, “Museum Beckoning Space Explorers.”
18. Art Workers’ Coalition, “13 Demands.”
19. Glucek, “Museum Beckoning Space Explorers.”
20. Fuller, *Critical Path,* 35.
21. Kepes, *Arts of the Environment,* 208.
22. Burnham, “Real Time Systems.”
23. Ibid.
24. On the political life of technical artefacts, see: Winner, Langdon. "Do Artifacts Have Politics?" *Daedalus* 109, no. 1 (1980): 121-36.
25. Goodyear, “From Technophilia to Technophobia.”

26. Tuchman, *A Report on the Art and Technology Program of the Los Angeles County Museum of Art*. A rather ambitious proposal, Pulsa's unrealized LACMA project would have seen the incorporation of radar scanning and radio devices in order to achieve the MoMA show's failed attempts to build an artificially intelligent feedback environment. Pulsa asked for a parcel of open land, ideally one square mile in area, in which to install their light and sound environment. The proposal also makes note of the various corporations Pulsa hoped would donate equipment, including RCA, Gilphilin, and Union Carbide.
27. Ibid.
28. Ashton, "New York Commentary."
29. Battcock, "The Politics of Space."
30. Kramer, "Participatory Esthetics."
31. Though the Pulsa archives and my interviews with members do not refer to second order cybernetics by name, this framework offers a helpful entry point for thinking through control. See also: Maturana and Varela, *Autopoiesis and Cognition*; Varela, Thompson, and Rosch, *The Embodied Mind*; von Foerster, *Understanding Understanding*.
32. Busbea, *The Responsive Environment*, 147.
33. Another idea related to this theme of complexity is what Pulsa calls "parallel processing," which refers to the simultaneity of divergent thought as opposed to strictly linear processes. See also: Minsky, Marvin. *The Society of Mind*. United Kingdom: Simon & Schuster, 1988.

34. Belgrad makes note of systems theorist Ervin Laszlo's definition of "systematicity," which we might also use to describe such boundedness of systems against undifferentiated chaos. See Belgrad, *The Culture of Feedback*, 47.
35. Clarke and Hansen, *Emergence and Embodiment*.
36. Wiener, *The Human Use of Human Beings*.
37. Clarke and Hansen, *Emergence and Embodiment*, 115.
38. Michael Cain, personal communication, September 6, 2020.
39. Clarke and Hansen, *Emergence and Embodiment*, 77–91.
40. Ratcliff, "New York Letter."
41. Oren, Michel, and Rumsey, David. "Michel Oren Interview with David Rumsey, 1989 May 15."
42. "8th Annual Avant Garde Festival. Press Release."
43. My use of the word "affordance" here follows J.J. Gibson's definition of the unique but constrained possibilities for use offered by a technical artifact. See Gibson, James Jerome. *The Senses Considered as Perceptual Systems*. Waveland Press, 1983.

Conclusion

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